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ABSTRACT

Detailed are the first ten years of the Sea Grant Program through 1976. The review is divided into three parts. Part I, Sea Grant Origin and Process, traces the historical development of the program and cites the program's philosophy. Part II, Sea Grant in Action, discusses marine resource development, marine technology, research and development, marine environmental research, marine education and training, and marine advisory services. Part III, Sea Grant Benefits, discusses specific benefits, national needs, and the future of the program. (BT)

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National Sea Grant College Program

The First Ten Years

By: E. W. Seabrook Hull

For:
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U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
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SE 029 378

Thanks, Credits and Kudos

Many people and organizations helped me to know and understand the National Sea Grant Program. It is not possible to name them all, though named or not I am indebted and grateful for their patient efforts and understanding. Among them are:

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. . . Those Sea Grant Marine Extension Agents who took the time to explain and show me what they are doing and how they are doing it. They are the linchpin of the whole Sea Grant effort . . .

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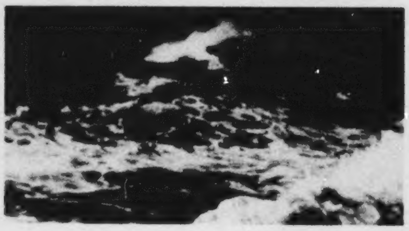


"Since ancient times man's relationship with the sea has been a significant one and one which has necessitated that man search for a way to harness the tremendous power of the sea for his own benefit. The sea has brought man both good and bad: It has been a life source, it has been a cause of death, and it has brought man new beginnings. The new beginnings which the sea can now provide have overwhelming implications for mankind's future in terms of future energy supplies and food resources. Scientists feel that the sea will provide the answers to these complex problems of survival and progress which face us in the future.

"The conclusion seems obvious: We must continue to support an educational endeavor which is teaching us to explore and exploit one of the world's greatest natural resources, the treasurehouse of the sea. Thanks to the Sea Grant College Program the great unknown of the sea is becoming more comprehensible, more manageable and an even more harmonious and helpful part of the world environment. This is our opportunity to initiate a second decade of cooperative scientific research and investigation in this important area."

Thomas P. O'Neill, Jr.
Speaker of the House of Representatives

The World of Sea Grant

There are no hard and fast delimitations to the world of Sea Grant. In general, it includes coastal lands to some moderate distance inland—say, 50 miles—their abutting bays, estuaries and tidal rivers and the offshore waters, seafloor, and subsoil of three great oceans, the Gulf of Mexico, and the Great Lakes. This means the coastal zones and offshore waters of 30 of the 50 States, the United States dependent territories and islands, and the Commonwealth of Puerto Rico.

The World of Sea Grant has 20,000 miles of general coastline, 93,311 miles of detailed tidal shoreline, 600,000 square miles of land and inland waters, more than 60,000 square miles of territorial sea, and some 830,000 square miles of water, continental shelf, and submerged lands. The 200-mile economic zone raises that last to more than three million square miles and includes the resources of the superjacent waters as well as of the seafloor and subsoil. In contrast, the land area of the 50 U.S. States is 3.6 million square miles.

The national continental margin contains the United States' largest untapped reserves of oil and gas. Since 1946, more than 17,000 wells have been drilled in the offshore waters of Louisiana, Texas, California, and Alaska. Many more States are being added to the list, and the pace of exploration is accelerating. Hand-in-hand is the need for expanded refinery capacity.

There is a similar demand for more electricity generating plants. The majority of those planned and being built is in the coastal zone; as the number of acceptable sites dwindles, there is pressure to locate them offshore.

These same waters contain the world's richest fisheries. In excess of 12 billion pounds of fish are taken from American offshore waters annually —up from 4.4 billion pounds in 1948. Virtually all of that expansion comes from increased foreign fishing efforts. In 1973, more than 150,000 full- and part-time U.S. commercial fishermen operating about 87,000 small and large fishing vessels caught 4.7 billion pounds of fin and shellfish with a landed value of $907.4 million. Foreign fleets just beyond the 12-mile limit caught 7 billion pounds. The World of Sea Grant also contains an estimated 3,000 fish-processing houses and wholesaling establishments employing some 90,000 people.

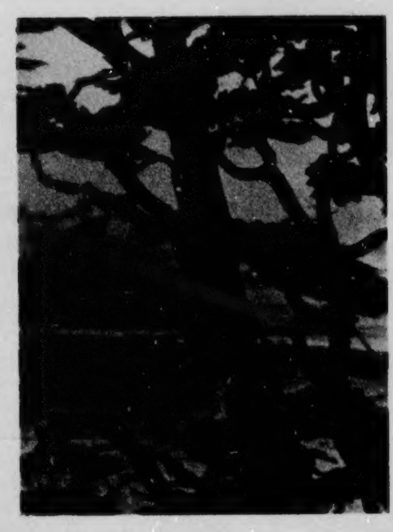
Some 624 counties and independent cities—a third of the U.S. total—are entirely or substantially within 50 miles of the shoreline. They contain more than 110 million people, 54 percent of the national total—compared to 46 percent in 1940 and 25 percent in 1850. Of 33 Standard Metropolitan Statistical Areas (a Census Bureau definition) with a population of a million or more, 23, with more than 63 million people, are in the World of Sea Grant. Twenty-five coastal counties alone accounted for 75 percent of the national population growth during the 1960–70 decade. Of some 274 counties actually on the ocean, Gulf of Mexico, or Great Lakes coasts, all but 55 showed population increases during this period.

Coastal zone populations earn an average of $500 more a year than those living inland. Of 15 States with a median family income of $10,000 or more, 14 are in the World of Sea Grant. Conversely, of 13 States with a median family income of less than $8,000 a year, only five are there.

With less than 17 percent of the national land area, the World of Sea Grant contains more than 40 percent of all manufacturing plants with 20 or more employees. Some 60 percent of all U.S. refinery capacity is found in just four coastal States—Texas, Louisiana, California, and New Jersey. All of the Nation's 630 million tons (1972) of waterborne foreign trade pass through the World of Sea Grant, as do some 243 million tons of domestic coastwise waterborne trade. Serving this trade are more than 1,600 marine terminal facilities in 132 ports with controlling channel depths of 35 or more feet. All but two of America's 10 busiest airports are in the coastal area.

Meanwhile, the United States remains absolutely dependent on imports for its energy requirements—some 40 percent of its need in 1975–76. The most efficient way to move this oil over water is in VLCCs (Very Large Crude Carriers). There are more than 500 of these giant ships transporting oil from the Middle East and elsewhere, but there is not one American port which can accommodate them. Ports undoubtedly will be built, and they unquestionably will be built in the World of Sea Grant, as will the special facilities required for offloading LNG (Liquefied Natural Gas).

Not counting houses, factories, docking facilities, offshore oil platforms, and the like, there are more than 3,000 major modifying structures in the World of Sea Grant, including 725 jetties, dikes, and breakwaters with an average length of 930 feet, 464 causeways; 525 pier bridges; and 1,165 dredged channels of at least 35 feet. It contains more than 3,500 miles of intracoastal waterways. Each year, some 140 million cubic yards of dredge spoil are disposed of in the region's open waters, and another 67 million cubic yards are dumped into special containment areas. Eight billion gallons of municipal wastes are discharged daily into coastal waters, while ocean dumping of other wastes is officially tallied at 12 million tons a year—mostly along the Atlantic coast, mainly industrial wastes and sludge from sewage treatment plants. In addition, there are some 10,000 polluting spills a year, mostly petroleum products and mostly in the World of Sea Grant.



If this World of Sea Grant is where people like to live and work—and obviously it is—it is also where many more like to play. Of 21,724 miles of U.S. tidal shoreline with a "recreation potential," 19,934 are privately owned. Of the publically owned 1,790 miles, access to 581 is restricted because they have been taken over by military bases, space stations, and other Federal installations. This leaves only 1,200 miles (less than 6 percent) for public recreation.

About 120 million people spend $15 billion a year on beach and other water-related recreation, and both figures are rising rapidly. Swimming, sunning, and other beach activities are the most popular coastal recreation. During the past 20 years, the number of marine sport fishermen has increased at a rate of 10 percent a year, while their expenditures have gone up at a rate of almost 11 percent. Some 16 million now spend more than $2 billion a year on this sport alone. Recreational boaters in the World of Sea Grant number over 20 million—of which 40 percent prefer sail—and their number is rising by at least 200,000 a year.

The World of Sea Grant contains some of the Nation's most important flyways and wintering areas for migratory waterfowl. These flyways are

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essential to survival of the species that use them, yet become unusable if occupied or modified by man. These waterfowl provide recreation for about two million hunters who spend a quarter of a billion dollars a year on this activity.

Estimates vary, but *at least* two-thirds of the marine fish caught by sport and commercial fishermen depend absolutely on coastal marshlands and estuaries for all or critical parts of their lives. Of the original 127 million acres of wetlands in the United States, only 75 million remain—a decline of 40 percent. The survival of this resource and of the land and sea animals that depend on it requires that it be left largely unmodified by human intervention.

Also in the World of Sea Grant, the National Park Service operates 22 major recreational areas—including 13 national parks and monuments, 9 national seashores and lakeshores—and 28 historic sites. The National Wildlife Refuge System includes 91 coastal refuges totalling some 20.4 million acres. The U.S. Army Corps of Engineers itself operates numerous recreational areas as adjuncts to its flood control and waterways activities. Additionally, there are many State-owned and operated coastal recreational facilities.

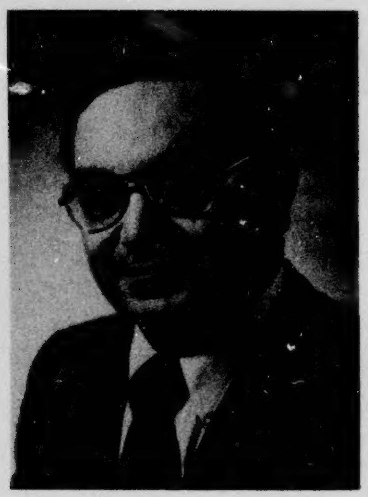
There emerges in this high-demand market still another compelling use of coastal and marine resources—one of potentially great national benefit. That is aquaculture, the husbanding of marine and freshwater plants and animals for the food industry. Where such farms are located, they cannot but restrict the extent to which such areas can be used for other purposes.

In addition to oil, gas, fish, and electric power, in addition to marine trade and recreation, in addition to new housing and industry, in addition to aquaculture and the wetlands conservation imperative, in addition to these and other pressures, the offshore and coastal World of Sea Grant also produces some 18 million tons a year of seashells (for cement and construction aggregate) worth more than $50 million and 100 million tons of sand and gravel (other than that needed for beach replenishment) with an onsite value of $250 million. Estimated reserves of these resources run to billions of tons.

From seawater itself we take $180 million a year of magnesium metal and compounds, bromine, salt, and freshwater. A variety of other metals and minerals—gold, platinum, titanium, copper, iron, zinc, manganese, glauconite, barite, phosphorite—are either being mined in small quantities from beaches and submerged coastal lands or have a near-term potential. Some of the Nation's most important phosphate deposits are found beneath coastal marshlands.

This thumbnail sketch does not cover all of the resources and activities in the World of Sea Grant. It is not intended to; that would take a book. Rather, it is designed to show the diversity and intensity of rising pressures on our coastal and marine resources, and their importance to the national well-being. Both the World of Sea Grant and its resources are finite.

There is no type of human activity that occurs inland that does not also occur in the World of Sea Grant. But a number of ocean- and estuarine-related activities occur only there. Add to this the greater complexity of



both the human and natural environments, and the crescendo of growth that characterizes the area, and one is faced with a management problem that is immense, intricate, and sensitive—and in the resolution of which the stakes are many and high. Indeed, it is a public management challenge without precedent both in scope and urgency. It is for the purpose of helping to develop the knowledge, tools, and skills necessary to this task that Sea Grant exists.

> ". . . the purpose of the National Sea Grant Program is to accelerate national development of marine resources, including their conservation, proper management, and economic utilization. This is to be accomplished through the sponsorship of programs which encompass (1) research applied to real and current problems, (2) adequate training and education of manpower, and (3) transfer of technology and knowledge to the people who need it in a form they can use."

Dr. Robert M. White
Former Administrator
National Oceanic & Atmospheric Administration
U.S DEPARTMENT OF COMMERCE

Sea Grant Origin and Process

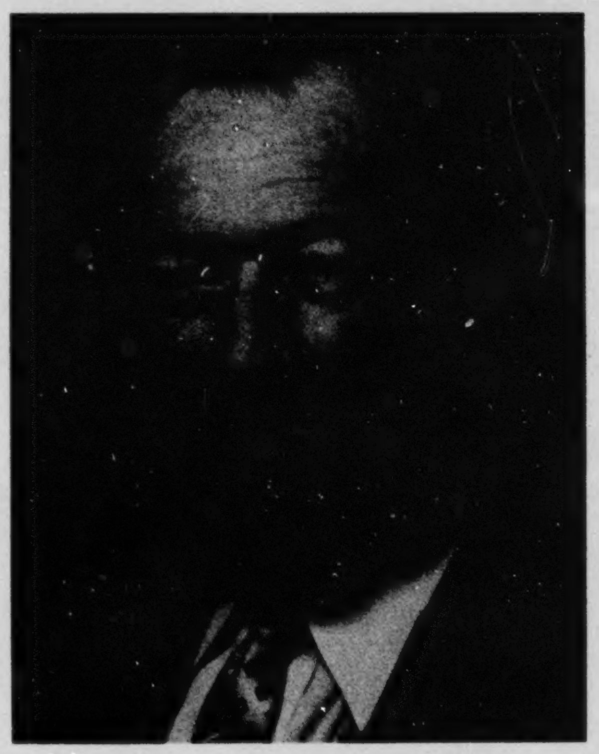
part 1

Introduction

The World of Sea Grant—the somewhat statistical essay—is more than a mere tally of superlatives. It is the diagnosis of a problem and the setting for a challenge. It describes in geographic, economic, demographic, and societal terms the tremendous variety and rising intensities of pressures of use and nonuse being imposed on the complex, diverse, delicate, and finite environment where man, land, and sea meet. America's coastal seas and bounded land are the locus of special resources of great variety on which the Nation increasingly depends for its future growth and well-being. For many reasons, it is where more and more people and industries want to settle, work, live, and play. It is also, therefore, where the greatest protection is required of the natural environment if its resources, both living and nonliving, both economic and abstract, are to be preserved for the use of this and future generations.

The problem is to understand the interrelationships of all these different kinds of human activities with each other and with the natural milieu on which they are imposed. The challenge is to transfer that understanding to the Nation as a whole and to devise and execute planning and management schemes to provide the greatest benefit to the greatest number of people in both the present and the future. This requires a fine balance beween exploitation and use, on the one hand, and conservation and preservation, on the other hand. This requires management and regulatory strategies and institutions which recognize the needs, expectations, and equities of the present without abrogating responsibilities to the future. It requires continuous and intimate two-way interaction with people and economic entities in ways that are responsive to needs, yet are neither abrasive nor divisive. It requires levels of knowledge and awareness among both managers and the general public that are without precedent. To accomplish these things in the least costly, most effective manner, to balance the do's with the don't's, and to resolve conflicts without creating new ones demands a very special approach in areas of great ecologic, economic, cultural, and political sensitivity. The first task has been to produce the processes by which such goals could be achieved most logically and most economically. One such process is the National Sea Grant Program of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA).

In the early 1940's, Dana E. Wallace—as Chairman of a committee of the Atlantic States Marine Fisheries Commission—outlined the parallel



"Just as the scholars in the Land Grant Colleges developed a passion for the land and led not only in ways to benefit by it, but also in the ways to preserve it—we must seek through a welding together of science, art, literature, engineering, medicine, law, public administration, and politics to develop a public which will not only homestead our new spaces in the sea, but colonize and civilize them through an integrated interdisciplinary education in the Sea Grant Colleges."

Dr. Athelstan Spilhaus

Point Judith, Rhode Island

between American agriculture under Land Grant and the needs of the U.S. national seas.

In 1963, Dr. Athelstan Spilhaus proposed a system of Sea Grant Colleges to do for fisheries and other marine resources what Land Grant had done for agriculture and the "mechanic arts" a century earlier.

The Sea Grant Colleges and Program Act was signed into law in 1966, and early in calendar year 1967 the Office of Sea Grant came into being. Today (1977), the National Sea Grant Program totals some $46 million a year, two-thirds of which is Federally funded and one-third of which is provided locally by the affected States and communities. As of June 30, 1976, this money underwrote 57 grants which, in turn, supported 692 separate projects. Working on these were 3,637 people, including 1,685 faculty and other professionals, 747 graduate students, 395 undergraduate students, 279 technicians, 358 clerical workers, and 173 others. Not all of these people work full-time on Sea Grant projects, however, and the full-time equivalent total was 1,910. These people and projects were distributed among more than 200 universities, colleges, junior colleges, technical schools, State agencies, and other organizations in 29 States, the District of Columbia, American Samoa, Guam, and the Pacific Trust Territories.

But Sea Grant is neither discerned nor understood by statistics alone. The statistics merely indicate Sea Grant's fiscal dimensions. This is the story behind those figures.

Philosophy and Precedent

Though Sea Grant is new, the basic idea comes from an earlier century. Jonathan B. Turner in 1850 first proposed "A Plan for a State University for the Industrial Classes." It was academic, even social, heresy. At that time, universities were elitist institutions turning out a favored few lawyers, doctors of medicine, educators, and members of the clergy. They were dedicated more to the transfer of existing knowledge than to the development of new knowledge. Turner proposed new institutions which would be open to all, at which agricultural and technologic subjects would be taught and where research and experimentation—the pursuit of new knowledge—would be undertaken.

It was a 12-year struggle over much opposition, but in 1862, Senator Justin S. Morrill's Land Grant Act was signed into law by President Abraham Lincoln. Twenty-seven years later, the Hatch Act authorized establishment of a system of agricultural experiment stations, and in 1914—52 years after the original Land Grant College Act—the Smith-Lever Act formalized the Agricultural Cooperative Extension Service. Given this country's then-abundant natural resources and the dynamic energy of its people, the system of Land Grant Colleges—probably more than any other single development—was responsible for the tremendous growth and excellence of this Nation's agriculture and industry, a record yet to be matched by any other nation.

Just 113 years after Turner's historic proposal, oceanographer, inventor, and writer Dr. Athelstan Spilhaus on September 12, 1963, asked a meeting of the American Fisheries Society in Minneapolis, Minn.:

> Why, to promote the relationship between academic, State, Federal and industrial institutions in fisheries, do we not do what wise men had done for the better cultivation of the land a century ago? Why not have Sea Grant Colleges?

The seed thus planted germinated, took root and grew into the National Sea Grant Program. Even as Land Grant was responsive to the great inland trek of America's burgeoning millions, so is Sea Grant responsive to the countermigration to the coastal area and the accelerating extension of human activities seaward.

There are similarities and there are differences between Land Grant and Sea Grant. A brief comparison of the two programs serves as a good introduction to the rationales and methods of Sea Grant. The three key words are *education, experiment*, and *extension.*

Education

Land Grant extended higher education to the needs and aspirations of a whole and uncommonly energetic Nation. Recognizing education's potential role in realizing economic, social, and political growth, it introduced great diversification of study disciplines and degree programs. That its initial emphasis was on the "agriculture and the mechanic arts" was a function simply of the needs and opportunities of the time. Its basic principles apply equally to the needs and opportunities of coastal and marine resources, which is the first rationale of Sea Grant.

As did Land Grant, Sea Grant fosters diversification of study disciplines and degree programs

Experimentation at the Scripps Institution of Oceanography, LaJolla, California

and basic changes in the ways institutions of higher learning think and function. New to the scene, for example, and of growing value to contemporary society are interdisciplinary educational programs, interdisciplinary team approaches to problem definition and solution, and the evolution of Sea Grant universities as centers of knowledge responsive to local, State, and regional needs. Because of Sea Grant, too, different departments within universities now work together in ways, and with results, that a few years ago would have been unthinkable. Institutions which once were bitterly competitive now work cooperatively. The late Dr. Milner B. Schaefer put it thus:

> Fulfillment of our destiny in the ocean requires a great deal more than the application of science and technology. This strange milieu, the sea, presents problems of economics, sociology, law, and philosophy to which old solutions and old traditions imperfectly apply. New institutions and new ways of thought require development. Our entry into this new realm requires the integration of many disciplines in both the sciences and humanities. We need to have scholars working closely together in the hard sciences such as physics, chemistry, biology, and mathematics; the soft sciences, such as sociology and economics; in engineering; in law; and others. There is an obvious need for the college of the sea to bring together men of all these disciplines to carry out their scholarly pursuits, research, and education in relation to the ocean . . .

The net effect of this has been to increase greatly the sensitivity of the participating universities to their public service roles and responsibilities. With this awareness has come a willingness to abandon traditional approaches in favor of those which encourage greater responsiveness to community needs and opportunities. This, in turn, enhances the institution's image in its community. In a very elementary sense, Sea Grant is responsible for bringing about a motivation among its participating institutions that is both exciting and rewarding.

Experiment

In 1850, Jonathan Turner urged that:

> To facilitate the increase and practical application and diffusion of knowledge, the professors should conduct, each in his own department, a continued series of annual experiments.

This philosophy was integral to the Land Grant concept from the very beginning; later, Congressional action only formalized what already was in being. Similarly, applied research and development is an essential ingredient of Sea Grant. As with the early Land Grant Act, the Sea Grant Act makes no provision for ocean or coastal experiment stations and, indeed, specifically prohibits the use of Sea Grant funds to buy land and facilities.

While some Sea Grant institutions have oceanographic laboratories, these seldom serve Sea Grant in the same way that experiment stations serve Land Grant. There is a difference between *experiment* (applied research) and *basic research*. Oceanographic laboratories are mostly oriented toward basic research which usually means high-seas research, with no goal other than the quest for knowledge. Sea Grant is oriented toward applied research, specific problem solving, and it is concerned almost exclusively with the coastal zone and contiguous offshore area. Funding for oceanographic research comes from sources other than NOAA Sea Grant—namely, the National Science Foundation and the Office of Naval Research—whose projects tend to utilize fully the capabilities and resources of laboratories funded and developed for that purpose. Similarly, the majority of the oceanographic research vessels was built for high seas work, and Sea Grant projects suffer under a low priority in the assignment of ship time.

Extension

In 1931, W. J. Kerr, then President of Oregon State Agricultural College (now Oregon State University), stated that:

> The first great task of the Land Grant Colleges was the development of science and its application in agriculture and industry . . . Except for the resident instruction and extension divisions, the benefit of the discovery might never have been put to general use.

In 1968, William Q. Wick, now Director of Oregon State University's Sea Grant College program, stated that:

> Putting America's oceans to work requires a major national commitment. The universities can play a significant role. Training students, however, is not enough. Applied research on ocean problems is not enough. But insuring the public use of knowledge through an organized advisory program—combined with training and research—is a first team effort.

The Cooperative Extension Service remains key to the success of Land Grant. Similarly, Marine Advisory Services (MAS), including the Marine Extension Service (MES), is a core element of Sea Grant success. Both assure timely and effective transfer of knowledge to those who need it. They also provide a real-time feedback mechanism for alerting managers and researchers of current and upcoming problems and opportunities. The Agricultural Extension Service concentrates on farmers and rural communities. Sea Grant has a much broader mission—providing research, education, analysis, advice, and counsel to local, State, and Federal agencies and to industry on the problems, constraints, and opportunities inherent in the use and management of the Nation's coastal and marine resources. Land Grant brought the widely diversified university into being. Sea Grant enables it to realize its full-service potential.

Marine Advisory Service Agent demonstrates weather gauge to volunteer in Virginia

At many institutions, Cooperative Extension Agents and Sea Grant Marine Advisory Agents work in close cooperaion—melding the long experience of the former in extension with the knowledge of the latter in the coastal zone, the sea, and the people and machines that make their way thereby. They make a potent team.

Financial Support

The way financial support is provided marks a difference between early Land Grant and early Sea Grant. The Morrill Act gave Land Grant Colleges an initial endowment of 30,000 acres of Federal lands for each Senator and Member of the House of Representatives to which the State was entitled. Subsequently, the Federal Government donated 11,383,000 acres under this provision.

In his early Sea Grant proposals, Dr. Spilhaus urged that:

> Sea Grant Colleges should be given grants of seashore and lakeshore, seawater and bottom within the territorial limits as their experimental plots to stimulate aquaculture in the waters and the prospecting and ways of exploiting the natural resources of the sea bed. These watery grants would serve the additional purpose of preserving tracts of seashore and open waters from the fiercely competitive pressures due to increase in population and industrialization—preserving them not only as natural habitats for ecological studies but as important nursery areas for high seas fish and residences for inshore food fish and shellfish.

The original Sea Grant Bill proposed that 10 percent of "all bonuses, rentals, royalties, and other sums" realized from exploitation of the mineral resources of the outer continental shelf be assigned to support the Sea Grant program. Neither proposal became law, so Sea Grant funding is subject to the vagaries of the annual Federal budgeting process, though with one important exception.

The law says that for every two dollars the Federal Government puts up at least one dollar must be provided locally. Contrary to some earlier fears, this matching fund requirement has proved to be a blessing. Because the States must put up *their* money, Sea Grant enjoys a degree of local use and involvement that many purely Federal programs do not. Because it is *their* money, the States make sure they get a fair return on their investment. Conversely, because the institutions depend on State and other local support—no matching funds, no Federal funds—they have a special incentive to be responsive to local needs. Not only is it an incentive that works well, but the results are so good that almost from the beginning, matching funds have exceeded the statutory 33.3 percent and, indeed, averaged out officially to something above 40 percent and unofficially (including support provided for Sea Grant projects but not tallied in official totals) 50 percent.

Local Response to Local Needs

An important characteristic in common is that both Land Grant and Sea Grant are locally planned, staffed, and managed. Land Grant has proved and Sea Grant is proving this to be a singularly effective way to anticipate and treat local needs and opportunities. This approach provides local, central, and accessible sources of knowledge, research, testing, and analysis. It combines a knowledge of local conditions, needs, and expectations with a continuing awareness of developments and practices throughout the United States and abroad. It can relate distant technologies, equipment, and experience to local requirements and, where existing technology or science is inadequate, conduct original research.

The local response capability with basic policy guidance from, and two-way dialogue with, Washington assures that Sea Grant, like Land Grant, also is responsive to national needs. Active involvement at the local level by scholars and extension agents alike serves as an early warning system of incipient national problems, because symptoms frequently are more evident in the field than they are from the remote perspective of the Nation's capital.

Mobilizing Existing Resources

The way Sea Grant functions, it does not so much create new institutions and capabilities as it mobilizes those that already exist to tackle new and exciting challenges. These are the talents and facilities already in being in the Nation's colleges and universities. Sea Grant serves as the catalyst and, through NOAA funding, provides the incentive for bringing these intellectual and physical resources to bear on the needs and opportunities of the communities those institutions serve. Because they do utilize largely existing people and facilities, an asset of considerable pragmatic value is created at a comparatively low cost to the taxpayer.

Direct Involvement

Continuous direct involvement is what makes both Land Grant and Sea Grant work. Local educators, scientists, lawyers, engineers, extension agents, and others deal directly with the affected people. They pose and try solutions to problems. They can see the results immediately and in real, not abstract, terms. And so can those they serve. The situation permits and encourages success. It is not only a matter of peer approval; there is a direct feedback loop which enables mistakes, as learning experiences, to contribute as much to overall progress as success. Indeed, continuous onsite participation reduces the possibility of serious error by encouraging early identification of faults and permitting the imposition of remedies before serious damage is done to either budget or reputation.

From a Proven Base

Throughout, the Land Grant-Sea Grant analogy holds true. The play is the same; only the scenery and dimensions are different. In some ways, Sea Grant is played on a somewhat bigger stage, for it addresses itself to a much broader spectrum of problem areas and to a rather more diversified constituency. But the principle of local response to local needs, the ability to see what's needed, what works, and what does not, and the trident thrust of education, experiment, and extension are the same.

Land Grant is old, established, and proven. Sea Grant is young, still evolving. It is not retracing Land Grant's long trek up the learning curve, however; rather, it starts from that proven, well-founded base—adopting, adapting, and innovating to best suit its special purposes. The crisis conditions that already prevail in the coastal zone, the rapidly rising importance of marine resources to the national future and, simply, the contemporary pace of events in the latter half of the 20th Century already demand far more of Sea Grant than was either required or expected of Land Grant in the middle of the 19th Century.

The record of performance Sea Grant has been able to establish in its first decade provides evidence that its contribution to America's future might be every bit as great as Land Grant's contribution to America's present.

Sea Grant: Process, Mechanics and Control

Dr. Spilhaus' proposal drew an immediate enthusiastic response. In August 1965, Rhode Island Senator Claiborne Pell introduced S. 2439 to provide for "the establishment and operation of Sea Grant colleges and programs of education, training, and research in the marine sciences and a program of advisory services relating to activities in the marine sciences . . ." In October of that year, under the strong leadership of the University of Rhode Island's (URI) Dean of Oceanography, Dr. John A. Knauss, a national conference on "The Concept of a Sea Grant University" was convened at Newport, R.I., and gave structure and substance to Dr. Spilhaus' proposal. The proceedings of that conference produced the following:

"A Sea Grant University . . . it is one of the most stimulating educational concepts in many years."
Senator Claiborne Pell

A Sea Grant College would be an institution of higher education devoted to increasing our Nation's development of the world's marine resources through activities in areas of education, research, and public service. A Sea Grant College would specialize in the application of science and technology to the sea, as in underwater prospecting, mining, food resources development, marine pharmacology and medicine, pollution control, shipping and navigation, forecasting weather and climate, and recreational uses. It would relate such application to the underlying natural sciences, which underly social sciences, as they are affected by, and in turn affect, the occupation and exploitation of the sea. Thus, a Sea Grant College would bring to bear the wide variety of intellectual resources usually associated with a university on the development of marine resources. We are not suggesting the establishment of new schools, colleges, or universities, but rather the development of this capability in State and private institutions already deeply involved in the study of marine sciences.

Florida's Representative Paul Rogers got the Sea Grant ball rolling in the House of Representatives with the introduction of H.R. 16559. Support

". . . I urged the Congress to approve this program to expand the ranks of our marine brainpower in order to develop the skills and technology necessary for marine exploration. Our returns will not only be financial, but this Nation will prosper with the development of the seas in this century under the Sea Grant College Programs, just as America has prospered as a result of the Land Grant College system established in the 19th Century."

Congressman Paul G. Rogers

grew in both Houses of Congress. A bill was passed, and on October 15, 1966, President Lyndon B. Johnson signed the Pell-Rogers Sea Grant College and Program Act into Public Law 89–688. Sea Grant started life in the National Science Foundation in February 1967, and in the following February, the first Sea Grant awards were made to Massachusetts Institute of Technology, California Institute of Technology, and Louisiana's Nicholls State College.

Since that modest beginning through June 30, 1976, 473 grants including more than 4,000 projects have been awarded with a Federal and local matching funds total of $217 million. In October 1970, under Reorganization Plan IV/1970, the Office of Sea Grant (OSG) was transferred from the National Science Foundation to the newly created National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, where it has remained.

Sea Grant's mission was and is to aid in the establishment of Sea Grant Colleges—a designation which must be earned by existing institutions. A prerequisite is demonstrated service through multidisciplinary approaches to solving problems and realizing opportunities in coastal and marine affairs. In 1971 the University of Rhode Island, Texas A&M University, Oregon State University, and the University of Washington became the first Sea Grant Colleges. Since then, the University of Hawaii, University of Wisconsin, University of California, State University of New York/Cornell University, State University System of Florida, University of Delaware, University of North Carolina, Massachusetts Institute of Technology and Louisiana State University have been added to bring the total in 1978 to 13.

The Sea Grant Charter

The Pell-Rogers Act was a pioneering document. It recognized the functional interrelationships and complexities of the human-land-sea system. It provided not only for research and development in the natural, engineering, legal, social, and economic sciences, but also for them to be considered in interdisciplinary concert as a total, dynamic, interactive whole. The Act, thereby, anticipated some of the most crucial imperatives of coastal zone management.

The Act provides for "Federal support toward the establishment, development and operation of programs by Sea Grant Colleges and Federal support for other Sea Grant programs designed to achieve gainful use of our marine resources . . ." Marine resources include "animal and vegetable life and mineral wealth." The Act emphasizes aquaculture which "can substantially benefit the United States, and ultimately the people of the world, by providing greater economic opportunities, including expanded employment and commerce; the enjoyment and use of our marine resources; new sources of food; and new means for the development of marine resources."

The Act defines "support" of marine development as:

scientific endeavors, relating to the marine environment, including, but not limited to, the fields oriented toward development, conservation, or economic utilization of the physical, chemical, geological and biological resources of the marine

Technical training at the University of Rhode Island

Research at the University of California Sea Grant College Program.

environment; the fields of marine commerce and marine engineering; the fields related to exploration or research in the recovery of natural resources from, and the transmission of energy in, the marine environment; the fields of oceanography and oceanology; and the fields with respect to the study of the economic, legal, medical, or sociological problems arising out of the management, use, development, recovery, and control of the natural resources of the marine environment.

In addition to a broad and flexible mandate, the Act also decrees to Sea Grant a broad realm as including:

the oceans; the Continental Shelf of the United States; the Great Lakes; the seabed and subsoil of the submarine areas adjacent to the United States to a depth of 200 meters or beyond that limit to where the depths of the superjacent waters admit of the exploitation of the natural resources of the area; the seabed and subsoil and similar submarine areas adjacent to the coasts of islands which comprise United States territory; and the natural resources thereof . . .

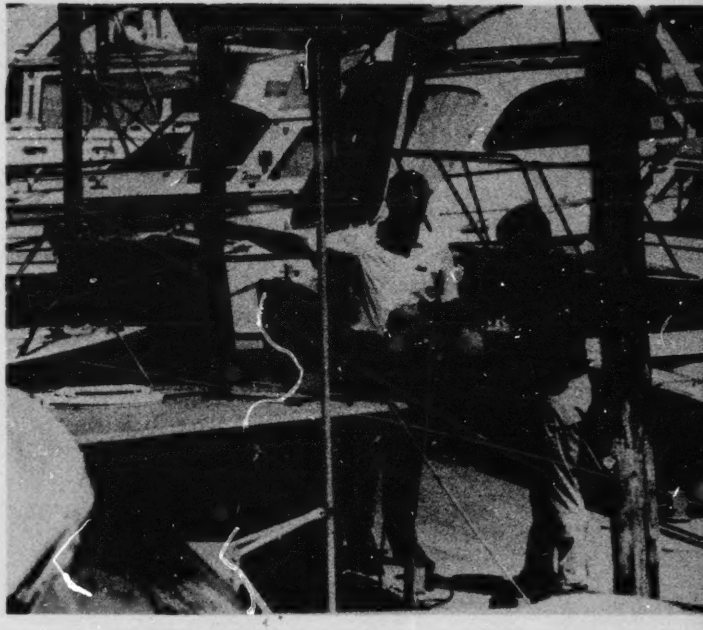
This does not mean that Sea Grant must go out and do all these things in all these areas. It is not a mandate for excess. Rather, it is a mandate for flexibility, for responsiveness to local needs and opportunities of whatever nature. The Sea Grant Act was not intended to, and did not until after legislative mandates for such efforts in 1976, produce a national program *per se*. Rather, the 1966 law authorized and encouraged the development of a *process*, a system of multidisciplinary centers of excellence capable of responding effectively in a great variety of ways according to local and regional demands and—in a broad and fundamental sense—in accordance with national interests.

The Act also defines the three main elements of the Sea Grant process as:

(1) Education and training in order to assure an adequate supply of marine-wise, trained professionals;
(2) Research in order to provide the necessary knowledge and technology; and
(3) Advisory services both to identify needs and opportunities and to transfer knowledge to those who would use it.

Three Basic Grants

Sea Grant awards three basic types of grants. They are designed to accommodate various levels of commitment and capabilities in such a way as to minimize the administrative load on OSG while assuring a maximum level of local control commensurate with sound quality control and the realization of Sea Grant objectives. The three types of grants are:



Marine Advisory Service Agent with boatowner.

(1) Institutional grants which go to institutions of higher learning, or combinations thereof, with an existing broad base of competence in marine affairs; and a positive, long-term commitment to Sea Grant objectives "as evidenced by commitment of the institution's own resources in the form of matching funds, creation of the organization necessary for management of the Sea Grant Program, establishment of interdisciplinary research teams, and development of advisory service mechanisms for strong interaction with marine communities in its region." Sea Grant Colleges are named from this group.
(2) Coherent Project grants which go to institutions which have some, but not comprehensive, competence in marine affairs. They enable such institutions to apply their expertise toward Sea Grant objectives and to develop the broader base of competence necessary to qualify for institutional support. Coherent Project support may also be used "to bring into the Sea Grant Program, on a more or less continuing basis, qualified entities which have rare or unique capability in a specialized field of marine affairs." Such entities need not be institutions of higher education.

(3) Project grants which go to individuals for clearly defined activities with outstanding merit and contribute to fulfillment of Sea Grant objectives. Project support is usually, though not exclusively, for one-year efforts.

Both Institutional and Coherent Project support presume a continuing effort through the years by the grantee institutions. In return for this commitment, an effort is made to assure continuity of Federal support. A college or university must have been in an institutional grant status for at least three years to qualify for consideration as a Sea Grant College.

Program Quality and Fiscal Control

How Sea Grant appears to function to the casual observer and how it actually functions are two quite different things. Technically, Sea Grant provides most support through institutional block funding. This implies lump sum payments to institutions with which they are free to do pretty much as they please within often quite broad limitations.

This is *not* the way Sea Grant works.

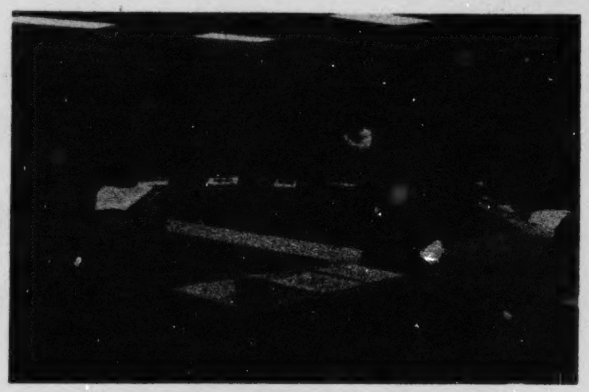
While the majority of Sea Grant funds is expended as block grants to institutions, the grants are made for specific programs which, in turn, consist of numerous individual projects. Before they are approved for support, the programs and each individual project undergo several layers and types of critical scrutiny. Once funded, they are subject to continual review for performance. Typically, the procedure is as follows:

Regular and frequent communication by staff members of the NOAA Office of Sea Grant with the institutional Sea Grant directors keeps the directors current on Federal budget developments and national interests and constraints. By the time proposals are submitted, most individual projects already have been discussed with OSG representatives and likely levels of support are known. This is the first level of control.

The local Sea Grant director does not act unilaterally or arbitrarily but has his or her own system of advice and review, such as: the Marine Advisory Services, the principal investigators, a Sea Grant executive committee drawn from within the institution, and a Sea Grant advisory council drawn from the community served by the institution and consisting, variously, of industry leaders, labor, civic groups, professional societies, State agencies, and local governments. Thus, both new and continuing projects are subjected individually to extensive internal and external review and control. The sharp competition for limited funds itself is a winnowing process. It is a tough business, and, generally speaking, only productive and responsive projects survive.

On the local level, then, the director is a granting center. This gives him or her a higher degree of control than if the position were merely a university administrator or departmental chairperson trying to coordinate disparate projects for which the principal investigators had obtained their support independently from one or more distant sources in Washington. Indeed, many university administrations welcome this aspect of Sea Grant as restoring centralized research authority to the universities. Sea Grant's multiproject grant approach assures primary review and control at the local level; it also assures administrative simplicity for OSG which otherwise would have to administer more than 10 times the number of grants it does now.

Once the local Sea Grant director forwards his or her proposal to Washington, a whole new review process begins. New project proposals are sent by OSG for critical screening to outside experts familiar with the proposed fields of investigation. This review frequently includes Federal and State agencies on which the work might impact. Concurrently, OSG staff program monitors carefully scrutinize the proposals, assuring that continuing projects are maintaining their focus, are making significant progress, are remaining relevant, and that national as well as local interests are being served. The results of these review processes go back to the local director, and if his or her proposed level of Federal support is too high, suggestions are made for cuts.



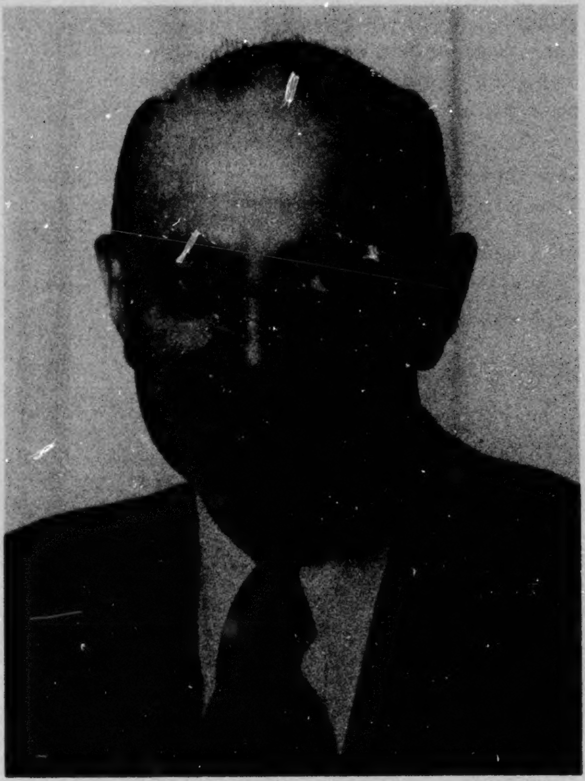
University of Delaware investigator explains research proposal to Sea Grant site visit team.

Meanwhile, a 6- to 10-person "site-visit" team has been named from the National Sea Grant Review Panel, the OSG staff, relevant Federal and State agencies and other Sea Grant institutions—including always a specialist in advisory services. Well in advance of the team's visit to the Sea Grant institution, copies of the proposal are sent to team members and to various Federal agencies (always including the National Marine Fisheries Service) which may or may not choose to be represented on the team.

The actual visit is an intensive 2- to 3-day affair. The first day, the institution staff presents its program and is questioned by the team. That evening the team meets in executive session to review the program project by project. The next day, the team meets with local Sea Grant management in a candid give-and-take session in which team members make their views known and the local Sea Grant personnel are given an opportunity to respond. This is a critical time in the project approval process.

Back in Washington, the NOAA Sea Grant program monitor prepares a report on the visit, obtains corrections and approval from team members, and forwards the finished product to both the local Sea Grant director and the full membership of the National Sea Grant Review Panel, which is given an opportunity to comment. This 15-person panel consists of university, government, and industry personnel and represents a broad mix of disciplines, interests and geographic regions. It meets formally twice a year to discuss, advise, endorse, and/or criticize both the overall Sea Grant effort and its constituent programs. This panel has guided national Sea Grant management since before the first institutional grant was awarded in 1968.

Thus, block funding, as practiced by Sea Grant, does not relinquish control. Quite the contrary, it assures much closer control and guidance of both money and project quality. At the same time, however, it encourages great flexibility in local responsiveness and in the development of useful knowledge and capabilities. At the institutional level, the director has both authority and responsibiliy to manage and mold his or her program. As previously noted, the director has a system of review processes and advice. Having local funding authority, he or she is able to assure coherence and coordination among the various elements of the program, to attract top talent, to instill the Sea Grant essence of service and, where



". . . Sea Grant directors have been chiefly responsible for the smooth functioning of the extremely complicated messianic activity necessary to induce vice presidents, deans, department heads, and professors in myriad scientific and technical fields to subordinate their individual aspirations to programs built around common themes and to pursue these programs in a totally coordinated manner."

Dr. Robert B. Abel,
Former Director,
National Sea Grant Program

indicated, to encourage interdisciplinary, interdepartmental, and interinstitutional team approaches. Add to this the subsequent layers of review and control at the national level, and the Sea Grant management method probably achieves closer program control than can be found in almost any other Federal granting program. The significant point is that this NOAA program achieves fiscal and quality control without imposing Washington's whim and will on local program content or method.

Getting It Going

> ". . . Sea Grant directors have been chiefly responsible for the smooth functioning of the extremely complicated messianic activity necessary to induce vice presidents, deans, department heads and professors in myriad scientific and technical fields to subordinate their individual aspirations to programs built around common themes and to pursue these programs in a totally coordinated manner."
>
> Dr. Robert B. Abel, Former Director
> National Sea Grant Program

At start-up, Sea Grant's first job was to get the process going—to explain and sell the concept and mechanics . . .

. . . of new levels of university responsiveness to community needs and opportunities;

. . . of adaptive education to meet the changing needs of contemporary society for new breeds of professionals and technicians;

. . . of the quest for solutions rather than merely the quest for knowledge;

. . . of the interdisciplinary approach to problem solving;

. . . of interdepartmental cooperation and coordination in both research and education;

. . . and of interinstitutional cooperation, rather than costly and sometimes duplicative competition.

This process could not be done by edict or the issuance of a handbook. It required a fine mix of logic, diplomacy, blunt talk, cajolery, pressure, and, of course, the enticement of a new source of funding. The only person who could do this was the local Sea Grant director. Clearly, he or she had to be a person of very special talents.

University administrators had to be sold on the idea that successful Sea Grant participation would strengthen the institution's community support, bring it money and prestige, strengthen the appeal and contribution of its educational programs, and, in general, add a new and vital dimension to the university's role in contemporary society. Though Sea Grant would require changes, these would in no way derogate the institution's traditional standards and responsibilities.

Faculty members had to be convinced that they could do useful, exciting, and rewarding work as part of a coordinated interdisciplinary team. This was not an easy task and, at some institutions, it is not done yet. Individual faculty members had grown increasingly independent, both of one another and of their administrations. Professional rewards and recognition were attuned to individual research and publication in highly specialized professional journals. In contrast, Sea Grant's goal was contemporary problem solving, with results immediately useful to society to be given prompt and wide dissemination—not only among planners, managers, legislators, and business executives, but also among the general public.

Measures of Success

How well the National Sea Grant Program has succeeded in realizing these objectives can be seen, in part at least, in the figures—the shift through the years from project awards to institutional awards and the increase in Sea Grant Colleges. Institutional awards presume that the recipient university system has interdisciplinary team approaches and adaptive educational programs, is responsive to community needs, is coordinating all applicable university resources within the State, has effective communications with its coastal and marine constituency, is contributing to its State's effort to manage its coastal and marine resources, is attracting industry interest and participation, and is working productively with local, State and Federal agencies. Winning the coveted Sea Grant College designation says that the institution is not only doing these things, but also is doing them well.

Sea Grant's record shows that:

■ In Fiscal Year 1968, a $7.9-million (Federal + matching funds) effort included six institutional, two coherent project, and 21 project grants in 18 states and the District of Columbia, with a funding distribution of 55 percent, 5 percent, and 40 percent, respectively. At that time, there were no Sea Grant Colleges. In Fiscal Year

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Sea Grant Table I

Program Status and Funding Summary

STATE/DEPENDENCY	HIGHEST PROGRAM STATUS (Fiscal Year 1976)	FISCAL YEAR 1976 FUNDING $1,000			CUMULATIVE FUNDING 1967–76 $1,000		
		Federal	Matching	Total	Federal	Matching	Total
ALASKA	Coherent Project	559.1	524.2	1,083.3	3,192.0	3,774.4	6,966.4
ARIZONA	Project	32.9	51.4	84.3	32.9	51.4	84.3
CALIFORNIA	Sea Grant College	2,767.1	1,936.8	4,703.9	12,993.7	9,913.8	24,907.5
CONNECTICUT	Project	47.5	24.0	71.5	309.1	638.8	947.9
DELAWARE	Sea Grant College	781.2	446.7	1,227.9	4,069.4	2,374.7	6,440.1
FLORIDA	Sea Grant College	1,330.9	1,166.8	2,497.7	8,770.6	5,799.6	14,570.2
GEORGIA	Institutional Program	583.0	524.5	1,107.5	2,397.1	2,072.5	4,469.6
HAWAII	Sea Grant College	1,635.6	991.0	2,626.6	9,510.9	6,296.1	15,807.0
LOUISIANA	Institutional Program	700.4	615.5	1,315.9	4,747.8	3,999.2	8,747.0
MAINE/NEW HAMPSHIRE	Coherent Project	993.3	622.1	1,615.4	5,265.5	3,171.3	8,436.7
MARYLAND	Project	76.4	47.6	124.0	649.1	331.5	980.6
MASSACHUSETTS	Institutional Program	1,423.6	894.9	2,318.5	5,477.7	3,535.3	9,013.0
MICHIGAN	Institutional Program	464.8	382.3	847.1	4,814.9	2,626.4	7,441.3
MINNESOTA	Project	34.6	35.3	99.7	99.8	55.6	4,155.4
MISSISSIPPI/ALABAMA	Coherent Project	575.0	363.9	938.9	2,505.7	1,914.4	4,420.1
NEW JERSEY	Coherent Project	220.1	155.9	376.0	880.2	481.7	1,361.9
NEW YORK	Sea Grant College	1,249.3	812.5	2,061.8	8,248.6	7,823.9	16,072.5
NORTH CAROLINA	Sea Grant College	835.0	417.5	1,252.5	5,002.2	3,945.3	8,947.5
OHIO	Project	------	------	------	172.5	98.6	271.1
OKLAHOMA	Project	90.0	45.0	135.0	503.0	251.5	754.5
OREGON	Sea Grant College	2,107.6	1,265.4	3,373.0	11,520.7	6,995.3	18,516.0
PENNSYLVANIA	Project	------	------	------	598.4	298.8	987.2
RHODE ISLAND	Sea Grant College	1,786.4	884.0	2,670.4	8,389.0	4,441.5	12,830.5
SOUTH CAROLINA	Coherent Project	360.0	191.3	551.3	1,252.2	707.2	1,959.4
TEXAS	Sea Grant College	1,499.0	982.3	2,481.3	9,699.9	5,205.6	14,905.5
VIRGINIA	Coherent Project	520.7	292.3	813.0	2,577.6	1,408.9	3,986.5
WASHINGTON	Sea Grant College	1,564.6	819.7	2,384.3	9,894.7	5,702.9	15,597.6
WISCONSIN	Sea Grant College	1,131.3	600.0	1,731.3	7,104.3	3,792.9	10,897.2
DISTRICT OF COLUMBIA	Project	19.7	9.9	29.6	477.7	270.0	747.7
GUAM	Coherent Project	------	------	------	200.0	163.9	363.9
AMERICAN SAMOA	Project	46.7	30.1	76.8	157.5	90.7	248.2
VIRGIN ISLANDS	Project	------	------	------	102.6	53.3	155.9
TRUST TERRITORIES	Project	55.1	68.4	123.5	191.4	260.2	451.6
PUERTO RICO	Project	------	------	------	30.0	25.0	55.0

1976, a $38.6-million effort included 15 institutional, 12 coherent support, and 25 project grants in 27 States, the District of Columbia, American Samoa, and the Trust Territories, with the funding spread at 74 percent, 19 percent, and 7 percent, respectively. And, there were 11 Sea Grant Colleges (See Table 1).

- More than 200 academic institutions are now involved in Sea Grant work.
- More than 200 industrial, association, and professional organizations are participating in Sea Grant projects, including many which contribute matching funds as well as time, facilities, and knowhow.
- Some 25 Federal and 220 State and local government agencies are involved in Sea Grant projects, both as clients and as participants.
- Sea Grant matching funds are budget line items in more than ten states, while in others, university budget increases are specifically earmarked as Sea Grant matching funds.
- Rhode Island, Michigan, and Delaware have named their Sea Grant programs as State coastal zone laboratories; New York, California, Texas, Louisiana, Oregon, and Washington, while not having taken such formal action, nevertheless rely on Sea Grant for the same kinds of services.
- Interstate cooperation is increasing—the Mississippi-Alabama and Maine-New Hampshire bi-state Institutional programs, for example, as well as the movement eastward of Hawaii's freshwater prawn farming technology to Florida and South Carolina and the transfer of Oregon salmon-farming knowhow to New England.
- While there is a healthy competition among Sea Grant institutions, there is also a willingness to learn from one another. Oregon led the way in developing a Marine Extension Service. Rhode Island led in fisheries training. Others learned from them both.
- Projects begun by Sea Grant are frequently picked up by other agencies for continued funding—Massachusetts Institute of Technology's electron beam water purification scheme is now funded by the National Science Foundation's RANN program, while the Coastal Plains Regional Commission is funding aquaculture projects begun by Sea Grant in the Carolinas.
- More Federal agencies are transferring funds to OSG to support projects in their mission areas.
- More Federal agencies are going directly to Sea Grant-developed capabilities for research and analysis.

The extent to which a program's capabilities and resources are used is a measure of its success and utility. The extent to which it cooperates with, and defers to, others is a measure of its maturity. On all counts, Sea Grant is building an enviable record. Another measure of success is the extent to which a program contributes to individual, local, regional, and national wealth, health and well-being—and, that is what the rest of this report is all about.

> "One fisherman from Newport came to me when I was appointed director of the Sea Grant Program. He said: 'I hope that when you get over to the Corvallis campus that you will straighten that place out.' I said, yes, I hoped so too—but what should I straighten out? His response was that all of the fishermen in this port are making more money today because of the Sea Grant program; they are better fishermen, and they take better care of their fish. He said that their attitude is more optimistic, and their understanding of the environment is better. 'And, they have no idea how they learned all this. Why can't you tell them that the university through Sea Grant is doing this?' "
>
> William Q. Wick
> Director, Sea Grant College Program
> Oregon State University

Sea Grant in Action

part 2

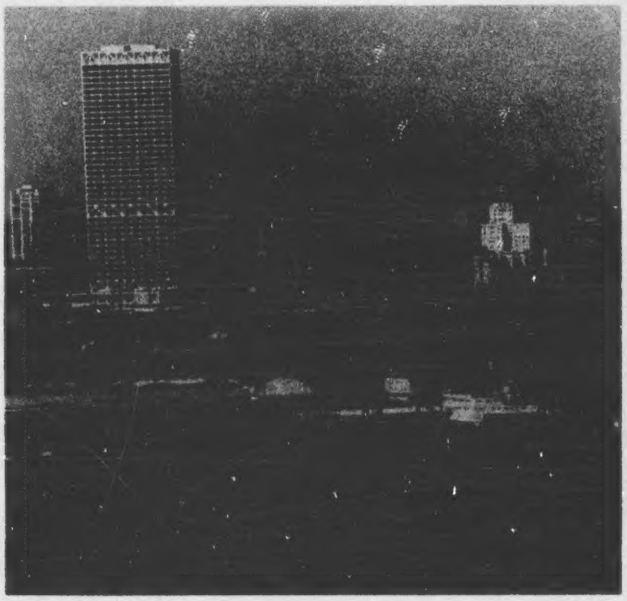
Introduction

Sea Grant builds no great monuments or citadels. It has no bridges, dams, interstate highways, or moon rockets. It is not that kind of program. It has numerous accomplishments, but none of their dimensions is either large or neatly discrete. Rather, Sea Grant is thousands of small actions—individuals responding to individuals, small groups interacting, problems identified and solved, information sought out and transferred, small solution-oriented research projects, subtle changes in educational processes, new perceptions of university roles and missions, and a better-informed public.

It is in the aggregate that these activities take on national substance. Even then it is difficult to answer the question: "What has Sea Grant done for America today?" How does one measure the success of such an effort? By a great variety of indicators, such as rising personal incomes, expanded tax bases, community satisfaction and optimism, fewer and less divisive conflicts, better environmental management, improved quality of life, more and better seafood delivered to the consumer, new job opportunities, reduced dependence on imports, higher export earnings, better-prepared professionals and technicians, and more responsive local, State, and national government. Some of these indicators are measurable; many are not; and either way, it virtually is impossible to assign quantifiable credit for these kinds of progress to Sea Grant or any other program. Too often, the only standard of measurement is what might have been *if* . . .

For reporting and budgeting purposes, OSG groups the several hundred individual projects underway at any given time into seven major categories, which, in turn, are subdivided into 81 classifications. The fiscal evolution of Sea Grant and the proportion of effort going into each major category are shown in Figure 1. Sea Grant projects are or have been active in 30 States, the District of Columbia, Puerto Rico, Guam, the Virgin Islands, American Samoa, and the Pacific Trust Territories. Only Illinois and Indiana, among the coastal States, have failed to take advantage of Sea Grant, while four inland states, Arizona, Colorado, Idaho, and Oklahoma are included.

With more than 750 separate projects in 35 different major political entities, without writing a book it is not possible to review the whole Sea Grant program either project-by-project or State-by-State. Neither is it possible to take one State's program and say, "This is typical." There is no "typical" program. Needs and perspectives vary from one region to another. Great Lakes States, for example, are concerned with water levels, erosion, ice, pollution, maritime transport, electric power plant siting, aquaculture, and underwater mining, but are in no way affected by the 200-mile offshore economic zone. The Nation's ocean and Gulf of Mexico States, however, are very much concerned with the meaning and impact of that zone. Except for Alaska and the Great Lakes



Milwaukee Harbor

States, none really is concerned with ice. Atlantic coast States consider the imminence of offshore oil exploration to be a crisis issue, while Louisiana, Texas, and California already have been that route. Sea Grant varies from one State to the next, also according to how and how well Sea Grant has developed and what kinds of community responsibilities each has assumed.

What follows is a selection of Sea Grant activities designed to show their variety, adaptiveness, responsiveness, methods, geographic spread, and benefits. The purpose of this section is to provide understanding and insight—a "feel" for the Sea Grant process, how it functions, how it contributes to more effective and more acceptable management, how it promotes more efficient exploitation and a better balance between exploitation and conservation, and how these things, as local efforts, help to build a sound underpinning for national well-being.

Sea Grant Figure I

Program Category Funding History[1]

PROGRAM CATEGORY	1968	1969	1970	1971	1972	1973	1974	1975	1976
Resources Development									
Number of Projects				76	126	145	173	169	155
Average Award/Project ($)				79,050	42,719	50,661	46,618	58,475	52,817
Total Program ($1,000)				6,007.8	5,382.6	7,345.8	8,064.9	9,882.3	8,186.6
Socioeconomic and Legal Research									
Number of Projects				28	46	57	63	76	57
Average Award/Project ($)				29,908	27,942	28,927	24,345	26,329	37,687
Total Program ($1,000)				837.4	1,285.3	1,648.8	1,533.7	2,001.0	2,148.2
Technical Research and Development									
Number of Projects				40	100	107	139	108	118
Average Award/Project ($)				68,699	49,548	43,586	34,485	42,537	37,399
Total Program ($1,000)				2,748.0	4,954.8	4,663.7	4,793.4	4,594.0	4,413.1
Environmental Research									
Number of Projects				82	124	163	165	155	180
Average Award/Project ($)				53,191	39,062	39,522	34,718	37,948	34,730
Total Program ($1,000)				4,361.7	4,843.7	6,442.1	5,728.5	5,881.9	6,251.4
Education and Training									
Number of Projects				64	78	79	90	76	85
Average Award/Project ($)				59,347	43,944	45,686	34,298	40,539	48,832
Total Program ($1,000)				3,798.2	3,427.6	3,609.2	3,068.8	3,081.0	4,150.7
Marine Advisory Service									
Number of Projects				63	71	78	113	101	113
Average Award/Project ($)				26,789	47,080	51,901	47,437	69,495	75,567
Total Program ($1,000)				1,687.7	3,342.7	4,048.3	5,360.4	7,019.0	8,539.1
Program Management and Development									
Number of Projects				22	39	38	56	49	44
Average Award/Project ($)				75,378	61,548	70,311	54,990	83,939	51,294
Total Program ($1,000)				1,658.3	2,400.4	2,671.8	3,079.4	4,113.0	2,256.9
Grand Totals									
Number of Projects				375	584	667	799	734	752
Average Award/Project ($)				56,264	43,899	34,609	39,608	49,826	47,801
Total Program ($1,000)				21,099.1	25,637.1	23,083.9	31,647.1	36,572.2	35,946.0

(1) All dollar figures include NOAA/Sea Grant funds plus local matching funds.

Marine Resource Development

Marine Resource Development projects are concerned with finding, surveying, developing, exploiting, conserving, and managing the living and nonliving resources of the sea. Sea Grant's role may range from the simple act of demonstrating the existence of a resource to the development of necessary technologies, demonstration projects, and the evolution of economic projections and marketing strategies.

Sea Grant policy is to seek the maximum cooperation and participation of the private sector whenever possible. Thus, fishermen give their time and their boats at no charge to try out a new net or piece of gear with their only expectation a better way for *everyone* to fish. Mining companies contribute both money and logistics to help develop better methods of underwater surveying, exploration, and mining.

Marine Resources Development is divided into (1) aquaculture, (2) living resources other than aquaculture, (3) marine biomedicinals and extracts, and (4) minerals. Table II shows the extent of these efforts.

Sea Grant Table II

Marine Resources Development
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget[1] ($-million)	Active Projects		Federal Funds		Matching Funds	
		Number	Average Cost Per Project ($)	($-million)	Per Cent of Total Federal Sea Grant[2]	($-million)	Per Cent of Total Program Budget[3]
Aquaculture	4.5	70	64,000	2.7	11.7	1.8	40
Living Resources (other)	2.4	54	44,000	1.6	6.7	0.8	35
Mineral Resources	0.6	14	43,000	0.3	1.4	0.3	46
Biomedicinals, Extracts	0.7	17	40,000	0.4	1.8	0.3	38
Category Totals	8.2	155	53,000	5.0	21.6	3.2	39

(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.

Aquaculture

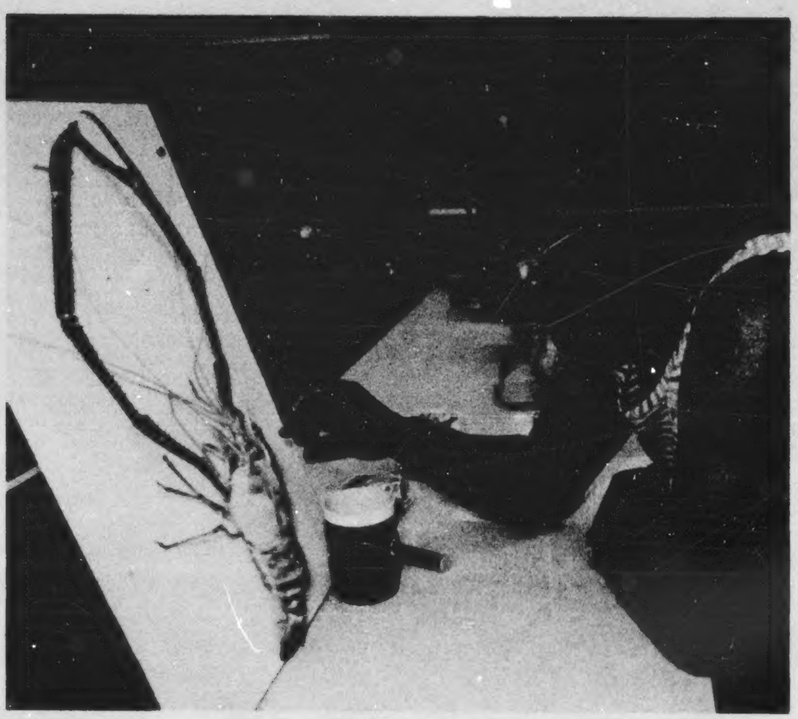
Aquaculture is to water what agriculture is to land. It is farming plants and animals that grow in water—which may be either fresh or salt water. To date, it has consumed the major share of Sea Grant's marine resources development budget. Abroad, it is a very old business, but most methods are labor intensive and uneconomic in the United States. That it can be profitable in this country has been well proven in the case of trout and catfish. The underlying thrust of Sea Grant-supported efforts is to increase the variety and profitability of the species that can be farmed. To minimize the economic risk, initial emphasis has been on high value species—though the long-term promise is one of large-volume production of low-cost sources of high-protein foods.

Because most coastal States border saltwater, the primary emphasis is on marine species. The University of Wisconsin, however, has brought both yellow perch and walleye pike farming virtually to commercial feasibility. Other Sea Grant-supported projects will enable marine species to be raised profitably hundreds of miles from the sea. Kansas City oysters or lobsters may one day be as famous as Kansas City steaks!

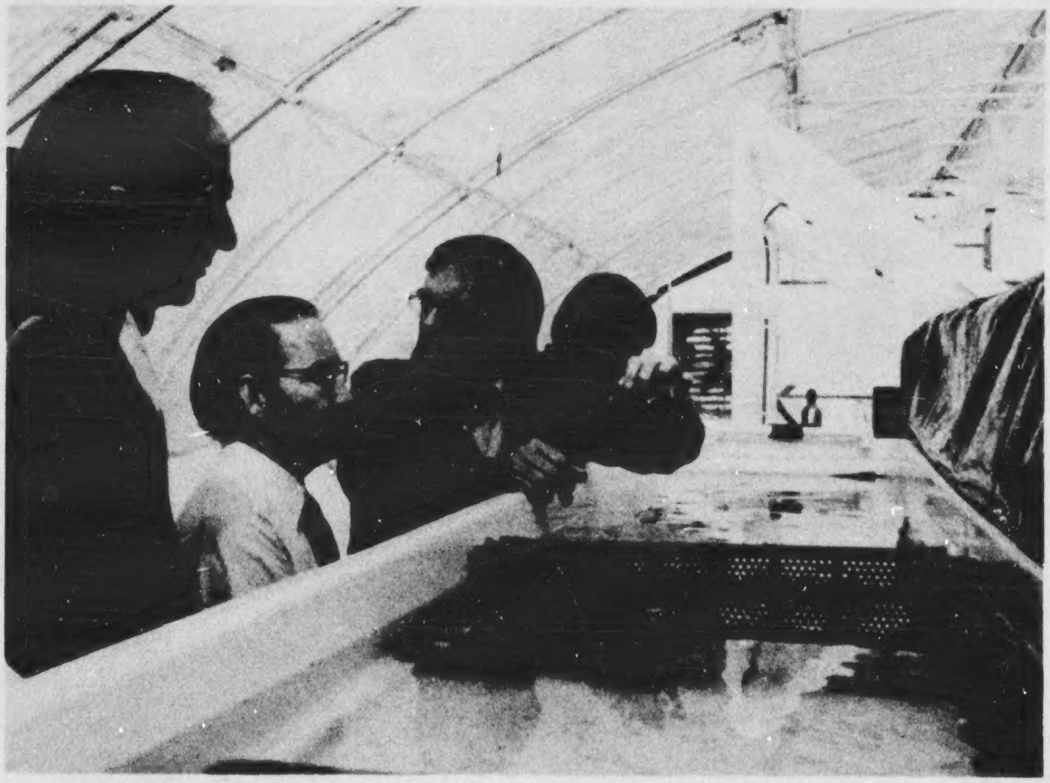
The benefits of successful aquaculture are manifold: new sources of high-demand, high-protein foods; an augmented national nutritional base; new jobs; new opportunities for venture capital; an expanded tax base; reduced imports; increased exports; and, when used for that purpose, enhancement, rebuilding, and transplanting of wild stocks.

The first task has been to build a sound technological base. Sea Grant support has been concerned with such efforts as: identification of most adaptable species, selective breeding for "most farmable" traits, diets, diseases, parasites, cannibalism, breeding in captivity, spawning on demand, and the design and engineering of efficient structures, materials, and systems. Among the species being studied are: "Maine" lobsters (*Homarus americanus*), giant Malaysian freshwater prawns (*Macrobrachium rosenbergii*), penaeid shrimp, salmon, dolphin fish (*Coryphaena hippurus*), yellow perch, walleye pike, rabbitfish (*Siganus* canaliculatus), oysters, clams, scallops, lugworms (for bait), giant brown kelp (*Macrocystis*), mussels, and Irish moss (*Eucheuma*).

Sea Grant-supported aquacultural research runs the gamut from open-range farming to completely closed cycle system. An example of the first is the ranch farming of salmon, first developed in Oregon and now being introduced in Washington, California, Alaska, and New England. Farmers raise young salmon in hatcheries and release them to the sea. New laws give them a preferential right to the salmon which later return as adults. Despite high natural mortality rates and a substantial catch at sea by both sport and commercial fishermen, this is turning out to be a quite profitable business. A small Sea Grant investment is resulting in many millions of dollars of private investment which, in turn, is expected to produce revenues in the tens of millions. This technique promises to more than offset the recent sharp decline in the natural harvest of salmon as



Malaysian Prawn research at the University of Hawaii.



Closed cycle aquaculture system at the University of Delaware.

well as to contribute materially to the rebuilding of natural stocks. It may well be applicable to other anadromous species, such as shad, herring, and striped bass.

Closed cycle systems—such as those developed for clams and oysters at Delaware and for salmon at Rhode Island—are particularly exciting. They mean that mariculture (farming ocean species) can be completely independent of proximity to the sea. And, because they are closed cycle systems, they eliminate any problems of pollution which accompany many farming operations. Ultimately, they may mean that many marine species will be capable of being produced close by their inland markets, thus bypassing many problems of preservation, storage, and transport.

There are many variations between open-range and closed-cycle aquaculture. Penaeid shrimp have been reared successfully in saltwater ponds close by the sea, in the heated cooling water from thermal power plants, and in abandoned quarries in West Texas. This last uses saltwater found in naturally occurring aquifers a few feet below ground level. Pan-size salmon are now being marketed in the Northwest which are raised in pens anchored in Puget Sound—a technique that is spreading to other parts of the country. North Carolina Sea Grant has found that dolphin (fish, *not porpoises*) are capable of being raised in tanks. Scientists at Woods Hole Oceanographic Institution have developed and demonstrated a multistep, integrated aquaculture system which uses the high-nutrient effluent from secondary sewage treatment to produce algae and oysters, while simultaneously providing effective tertiary sewage treatment.

The extent of Sea Grant involvement varies widely from one project to another. It may provide most of the support for original research, or it may step in along the way to provide lesser though critical support. Multi-institutional cooperation is a common feature of Sea Grant aquacultural research. California, New York, and Rhode Island closely coordinate their lobster farming work—all of which enjoys Sea Grant support. Hawaii is providing its basic *Macrobrachium* know-how to both Florida and South Carolina and is participating in efforts to adapt the technology to those States' different climates. Both Oregon State University and the University of Washington are cooperating in the transfer of various salmon farming techniques to northern New England.

Frequently, both State and Federal agencies as well as industry and academia cooperate on projects. Initial research on the pen-rearing of salmon, for example, was carried out by the National Marine Fisheries Service; as the project progressed, several Washington State agencies, the University of Washington and Domsea Farms, Inc. (a private firm), all became involved. Domsea believed in what it saw and is now harvesting more than 1,000,000 pounds a year—at an average price of $1.50 per pound—and is still building. Sea Grant, University of Hawaii's Marine Plant Agronomy Program, and Marine Colloids, Inc., (a private U.S. firm) have cooperated in establishing more than 1,000 new Irish moss (*Eucheuma striatum*) farms in the Philippines and other Pacific Rim countries and U.S. territories. This effort produced a tenfold increase in one year in world production of kappa carrageenan and solved a serious shortage, which was especially acute in the United States, where carrageenan is an important prepared foods additive.

Sea Grant's aquaculture program is moving into the critical phase now, where it moves from research and experimentation into commercial production. With successes already scored in several States in salmon, oyster, lugworm, kelp, Irish moss, and clam farming the prognosis is good, if not exciting. Already the subject of millions of dollars of investment and multimillion-dollar revenue levels, aquaculture in the United States and its dependencies has the potential for becoming a major source of food and a major national economic activity. It is an area in which Sea Grant has played and continues to play an important pioneering role.

Fisheries

In the last 20 years, the world fisheries catch has gone from 40 million to 70 million metric tons a year. The U.S. catch has remained static at 2.2 million tons, while both per capita fish consumption and total population have increased. The United States supplies less than half of the Nation's needs. The import bill to make up the difference is some $2 billion a year. Our contiguous ocean waters produce more than enough fish to fill our needs, but they are either caught by foreign fishing fleets, or they are not caught at all. The newly enacted 200-mile offshore economic zone is expected to give Americans fair and reasonable access to stocks which to date have been largely denied to them.

Commercial fisheries support may come from any of Sea Grant's major project categories—gear development under technology research and development, or marketing under socioeconomic and legal research. Contributions range from discovery of new stocks of fish and improved fishing methods, to assistance in writing legislation, better seafood processing, and waste management (See Table III). The effort is local and addresses problems and opportunities of specific fisheries. It is frequently a cooperative effort among Sea Grant institutions, State agencies, Federal agencies (such as NOAA's National Marine Fisheries Service, NOAA's National Weather Service, Internal Revenue Service, and the Environmental Protection Agency), the seafood processing industry and, always, the commercial fishermen.

Key to the whole effort is the Sea Grant Marine Advisory Services which maintain continual, close contact with the local fisheries community. It spots needs and opportunities, proposes solutions, and, where appropriate, brings in Sea Grant institution

A SEA GRANT
AQUACULTURE CASE IN POINT

Ranch Farming Salmon

The NOAA Sea Grant investment in ranch farming of salmon was $375,000 over a 9-year period—for hatching techniques, pilot demonstration, etc. What's the payoff? Several companies have made a commitment. Others seek licenses. Let's just look at one of them—the wholly owned Weyerhauser subsidiary, Oregon Aqua-Foods. Just about halfway to full output, it has proved the percentages in practice.

By 1980 and after a $6- to-$10 million investment, its operation will look something like this:

Each year the company will hatch and release 40 million chum salmon smolts (young salmon) to the sea. Of these, roughly 37 million will fall prey to natural predators. Of the remainder, U.S. commercial fishermen will catch over one million (market value, $15.1 million); sport fishermen, 400,000 ($5.6 million); and Oregon Aqua-Foods will harvest 800,000 (a fish return of 2 percent worth $11.2 million).

Aside from new jobs, exciting opportunities for investment capital, and a considerable addition to the national nutritional base, that is a $26.3 million product from one company's efforts alone. Multiply that by 15 to 30 other companies on the United States east and west coasts. . . .

Much of the new salmon production will be exported, helping our balance of payments, and helping to fight inflation. And, don't forget the tax base. The poundage tax commercial fishermen must pay on a million salmon is $376,000—more taxes in one year than the whole Sea Grant investment. That doesn't count personal and corporate income taxes, and property taxes, at both the State and Federal levels. Talk about payoff. . . .

scientists, engineers, technicians, economists, whatever. New information and improved gear are passed on to the fishermen by the marine extension agent, who then rides herd on its initial application to help in any debugging that may be necessary.

Sea Grant Table III

Services to Fishermen

- Develop greater knowledge of fishery population dynamics.
- Identify yields and market potentials of underutilized species.
- Expand resources by stock rebuilding and species transplants.
- Describe ecological requirements of important species.
- Define effects of natural and human environmental modification.
- Study fish predators, parasites and diseases, and their control.
- Introduce and test improved fishing gear and methods.
- Develop better fish handling, processing, and distribution techniques.
- Explore new fish and fish-product markets at home and abroad.
- Expose fishermen to better bookkeeping and management methods.
- Inform fishermen of various sources of capital financing.
- Make fishermen aware of available Federal and State services.
- Establish liaison between fishermen and regulatory agencies.
- Mediate disputes with other users of marine resources.
- Be alert to potential conflicts and work to avoid them.
- Assist local, State, and Federal agencies in fisheries management.
- In general, work to upgrade the national commercial fisheries effort.

Sea Grant tries not to reinvent the wheel. It first searches existing technology. If this proves fruitless, it then invents to order. It has been quite successful on both counts. As examples of technology transfer, Rhode Island Sea Grant introduced European pair trawling to its Point Judith fishermen with spectacular results. By this technique, two boats hauling one large net between them can catch more than three times what each could catch fishing alone. Doing is proving, and pair trawling is now spreading up and down the east coast. The cost to Sea Grant was the travel expense of one Irish fisherman to the United States to explain it. Similarly, University of Georgia Sea Grant debugged and adapted the never-to-then quite successful Gulf of Mexico "twin trawl"—substituting two smaller, side-by-side nets for one larger one—to the needs of southeast Atlantic coast fishermen, with a 60 percent improvement in catch efficiency. Again, it worked, and the practice is being adopted by others. As yet another example of successful technology transfer, Hawaii Sea Grant showed how modern scuba gear and manned submersibles could be used to survey, manage, and harvest precious coral—resulting in a major expansion of this industry while virtually eliminating dependence on foreign coral sources. Now this technology, too, is being transferred elsewhere, namely to the U.S. Pacific Trust Territories.

Inventing to order has been equally successful. The Massachusetts Institute of Technology Sea Grant designed, and fishermen have tested successfully, a hookup block for trawls which greatly simplifies this operation and reduces the possibility of injury. Oregon State University developed, and industry is now producing, a simple and inexpensive hydraulic power takeoff for outboard motors. This increases fishing efficiency and takes a lot of the sweat out of the Oregon and Washington dory fisheries for both coho salmon and dungeness crabs. Rhode Island Sea Grant has combined the fishermen's knowledge of their prey's habits with wind tunnels, tow tanks, computers, and other modern tools to design an entirely new high-rise bottom trawl which, having proved in practice to be more efficient, has spread to other States—including Massachusetts, New York, New Jersey, the Carolinas, and Oregon.

That is the way its goes: problems identified, solutions developed and tried. Usually, the suggestions are enthusiastically received by the

A SEA GRANT

MARINE RESOURCE CASE IN POINT

Precious Coral

The NOAA Sea Grant Investment in Hawaii's coral industry is $148,500 over a 5-year period to discover new coral beds, develop conservative harvesting techniques, and establish the bases for resource management within the bounds of maximum sustainable yield. What's the payoff?

When Hawaii Sea Grant began this work in 1971, the main coral collecting company, Maui Divers of Hawaii, Ltd., had 50 employees and gross sales of $500,000 a year. Hawaii's coral jewelry was some 90 percent dependent on imports for its raw materials, and supplies were drying up while prices were rising.

In 1974, the company grossed $7.8 million (retail value some $14 million) and had 214 employees. A much expanded coral jewelry industry depended on imports for less than a quarter of its supplies. New kinds of precious coral had been discovered, and techniques had been developed for selective harvesting to depths of 1,200 feet. Though its original investment in 1971 was $101,500, by 1975 Sea Grant was out of it entirely, and the State of Hawaii and private industry together had invested $294,277. This is the way Sea Grant is supposed to work: recognize an opportunity, do what is necessary to show the way, and then step back in favor of local efforts, whether State, private, or both.

This one has already more than repaid the investment in new tax revenues and will continue to do so over and over again. As a case in point, Maui Divers paid or withheld $556,934 in taxes in calendar year 1974.

fishermen; they catch more fish, save money, and are safer.

Discovering new stocks of fish and finding markets for known but underutilized resources is also an important Sea Grant function, which not only helps to meet domestic demands but also can strengthen the export potential of the American fishing industry. Toward this end, Oregon State Sea Grant has identified massive stocks of anchovy off its shores—enough possibly to make the United States a net exporter rather than a net (and heavy) importer of industrial fish and fish meal. Texas A&M University is targeting in on some way to land economically the hundreds of thousands of tons of "trash fish" thrown overboard each year by Gulf of Mexico shrimpers. Rhode Island is developing fishing methods and exploring markets for squid, which are plentiful in New England waters. California Sea Grant is defining the market potentials for both squid and sea urchins, while Wisconsin already is test marketing products made from such Great Lakes nuisance fish as alewives, burbot, and suckers.

Fisheries management is also an important area of Sea Grant research. Several studies of the meaning of, and management strategies for, extended fisheries jurisdiction have been completed covering different aspects of the problem in different parts of the country. Many were started long before Congress passed extended jurisdiction (200-mile) legislation. Some are quite comprehensive. As a result, when the law was passed, much of the groundwork already had been done. It was a situation that was thoroughly understood, and many alternative approaches to management and exploitation already had been devised, analyzed, and compared.

Sea Grant contributions to fishery management, exploitation, and conservation are many and varied—too numerous and too diversified to cover them all here. They range from development of laser and freeze branding techniques which enable crabs, lobsters, and other crustaceans to be tagged and followed through several molting stages, to the development of effective and economical acoustic fish counters and computer models of important fisheries, to the evolution of management criteria of intertidal resources under increasing recreational pressures, to the development of more efficient and sanitary seafood processing techniques. Proof that salmon sniff their way to their home streams and can be imprinted with artificial odors and drawn back to entirely different streams was developed through Sea Grant research, also. Sea Grant fisheries projects by States are shown in Table IV.

Sea Grant Table IV

Sea Grant-Supported Fisheries Projects

ALASKA
- Bivalves and Mollusks–*Biology*
- Snow Crab–*Biology*
- Shellfish Poison Test
- Marine Organisms–*Coding*

ARIZONA

CALIFORNIA
- Salmon–*Osmoregulation*
- Anchovy and Herring–*In Humboldt Bay*
- Squid–*Marketing*
- Spiny Lobster–*In Surf Grass*
- Kelp Bed Fish

CONNECTICUT

DELAWARE
- Delaware Bay Food Resources

FLORIDA
- Spiny Lobster–*Biological Attractants*
- Blue Crab–*Migration*
- Marine Invertebrates–*Pathology*
- Bacteria–*As Marine Pathogens*
- Virology–*Protection of Marine Organisms*
- Commercial Fish–*Egg and Larva Abundance*

GEORGIA
- Offshore Fisheries Survey
- Mariculture Support

HAWAII
- Precious Corals–*Resource Survey*
  - *Ecology and Growth Rates*
  - *Harvesting Techniques*
  - *Management Scheme*
- Fish Eggs and Larvae–*Ecology*
  - *Effects of Pollution*
- Tuna Bait Resources

LOUISIANA
- Finfish, Shrimp, and Crabs–*Resources Survey*
- Fisheries Resources–*Migration*
  - *Distribution*

MAINE/NEW HAMPSHIRE CONSORTIUM
- Shellfish–*Red Tide Toxins*
- Oysters–*Cell Cultures*
- Salmon Pancreas–*Infectious Disease*
- Potential of Fish Disease Service
- Crabs–*Biology*
  - *Population Dynamics*

MARYLAND
- Shellfish Bacteria–*Incidence*
  - *Survival*
  - *Pathogeneity*
  - *Estuarine Ecology*

MASSACHUSETTS
- Fish–*Effects of Hydrocarbons*
- Fish–*Tagging and Population Studies*

MICHIGAN

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM
- Artificial Reefs–*Development*
- Marine Animals–*Parasites*
- Ciguatera in Fish

NEW JERSEY
- Shelf Bivalves– *Growth*
  - *Mortality*
  - *Age Distribution*

NEW YORK
- Clam Industry–*History*
  - *Resources*
- Shellfish–*Diseases*
  - *Viral Flora*
- Fish Protein Industry–*Potential*
- Fisheries–*Economic Evaluation*
  - *Social Value*

NORTH CAROLINA
- Estuarine Detritus–*Nutrition*
  - *Bacteria in Food Chains*
- Green Turtle–*Salmonella*
- Fungal Diseases of Economic Species

OHIO

OKLAHOMA

OREGON
- Anchovy–*Population Studies*
- Flatfish–*Production System*
- Albacore–*Research Program*
- Salmonids–*Immune Responses*
- Clams and Shrimp–*Microsporan Diseases*
- Pelagic Fisheries Environment

PENNSYLVANIA

RHODE ISLAND
- Regional Fisheries Management
- Fish Pathology
- Underutilized Species Development–*Red Crab*
  - *Squid*

SOUTH CAROLINA
- Menhaden–*Population Dynamics*

TEXAS
- Sport Fish Populations

Fish and Shrimp–*Parasites*
Microbial Diseases
Coastal Waters–*Potential Health Hazards*

VIRGINIA
Cownose Ray–*Management*

WASHINGTON
Resource Assessment–*Acoustic Techniques*
Salmon–*Bases for Management of Fishery*

WISCONSIN
Whitefish–*Population Statistics*
Environmental Requirements
Lake Michigan Sucker Populations
Lake Trout and Whitefish–*Reproduction*
Salmon–*Environmental Preferences*

DISTRICT OF COLUMBIA

AMERICAN SAMOA

GUAM
Deep Water Shrimp Studies

TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO

NOTE: This is not a complete listing of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

Everywhere the procedures are the same: local response to local needs. That is where the action is, and that is where Sea Grant is—generating more and better jobs; increasing efficiency and safety; fostering better resource management; getting a better quality and wider selection of fish to the consumer; spotting, avoiding, and resolving conflicts.

Marine Biomedicinals and Extracts

Most of today's drugs and pharamaceuticals are derived from studies of land plants and animals—digitalis from foxglove, penicillin from the molds *Penicillium notatum* and *P. chrysogenum*. The sea is a new and largely unexplored resource, which scientists have only just begun to examine for this purpose. Sea Grant plays a small but significant role in this effort. Screening and testing biologically active compounds is challenging, but frequently slow and tedious. The potential, however, is great. Compounds already have been isolated which show promise in a wide variety of applications ranging from treatment of leukemia, cancer, and heart ailments, to agricultural pesticides, antibiotics, and antifoulants for ships' hulls.

University of Oklahoma scientists, with Sea Grant support, have supplied hundreds of marine extracts for testing by the National Cancer Institute—104 of which are active against leukemia and 30 of which are active against human cancer. This is a very high activity yield—more than four times that realized with terrestrial plants. Extracts from 12 marine species have shown bioactivity in cardiovascular systems, indicating potential in the treatment of heart ailments and hypertension.

University of Washington Sea Grant researchers have started a minor industrial revolution with their work on chitosan, a polymer derived from the shells of shrimp, crabs, and lobsters. It began as a project to solve the waste problem in shellfish processing houses. The researchers have converted an important part of that problem into an economic asset. They have found uses for it in nonwoven fabrics and paper, where a 1 percent addition hikes wet strength by 44 percent and greatly improves printability. Scientists at the Massachusetts Institute of Technology, with Sea Grant support, are using X-ray and electron diffraction techniques to determine the different chitosan source materials and processing methods. University of Delaware investigators have devised techniques for precipitating chitosan in crystalline fibers with a potential for use as food wraps, absorbable surgical sutures, and biological membranes.

Among other products of this research are:

- Development at the University of Washington of a fast, sensitive, and inexpensive way to determine calcium ion concentration in blood serum using the protein Aequorin extracted from the jellyfish *Aequorea aequora*, which is being test marketed by the Sigma Chemical Company.
- Isolation of organic compounds from the macrophytes *Chara foliolosa* and *Cleocharis microcarpa* by University of Southern Mississippi scientists. The compounds inhibit the growth of blue-green algae and may lead to synthetic products for controlling algae in a variety of applications, including sewage lagoons, aquaculture ponds, and swimming pools.
- Discovery by researchers at the Agricultural

Experiment Station, Geneva, N. Y., that an enzyme from the digestive system of surf clams catalyzes the hydrolytic breakdown of very stable carbohydrates—giving it a potential in the treatment of food processing wastes and the dissolution of dental plaque.

- Development by University of Rhode Island Sea Grant scientists of a rapid, reliable chemical test for the presence of toxins responsible for paralytic shellfish poisoning which enables precise limits of infected areas to be determined, thus enabling shellfish beds that might otherwise be closed to be harvested.
- Identification by University of California scientists of 48 new marine algal extracts, including the first natural terpene, an antifungal hydroquinone, an antibiotic active against Staphylococcus, and a possible system of natural (thus, biodegradable) agricultural insecticides.

Table V provides a brief summary of Sea Grant-supported drugs and chemicals from the sea projects.

Minerals from the Sea

As landside resources of important minerals continue to be drawn down and as environmental and political constraints limit access to those that do remain, the economics of marine minerals becomes more attractive. Significant reserves of many important minerals are known to exist in the deep ocean, on the continental shelves and slopes, and under the Great Lakes.

Sea Grant is mainly concerned with comparatively shallow water deposits. Though this category of effort is one of Sea Grant's smallest, it is an activity with exciting potential and one in which industry shows considerable interest.

One of the most active programs is at the University of Wisconsin, which includes: development of a hydrocyclone for underwater separation of magnetite (an iron ore) from sand; a microchemical analysis system for isolating manganese, cobalt, copper, and nickel from other materials in manganese nodules; and more efficient underwater survey and exploration techniques which have been used in both the Great Lakes and Alaska. Wisconsin Sea Grant researchers also have discovered and assessed both copper and manganese nodule deposits in Lake Michigan and Lake Superior.

Elsewhere, New York scientists have discovered and evaluated vast deposits of construction aggregates in Lake Erie; California researchers have inventoried its offshore sand and gravel resources; North Carolina investigators have identified recoverable deposits of quartz gravel, shell gravel, peat and clay; Rhode Island scientists have analyzed the economics of offshore sand and gravel recovery; and Hawaii researchers have discovered shallow-water manganese nodule deposits within the Hawaiian archipelago with a platinum and rare-earth content believed to be high enough to make them commercially attractive. The Hawaii program also has pinpointed offshore deposits of sand for replenishment of its valuable beaches and, under technology research and development, has developed and tested a prototype of an underwater sand recovery device.

All of these accomplishments were realized under Sea Grant auspices. Table VI shows Sea Grant-supported marine minerals activities.

Manganese nodules from the sea bottom.

Sea Grant Table V

Sea Grant-Supported Drugs/Chemicals Projects

ALASKA

ARIZONA

CALIFORNIA
Marine Algae–*Antiviral Extracts*
Bacterial Fouling–*Antibiotic Control*
Seaweed Products–*Mariculture Applications*
Agriculture Applications

CONNECTICUT

DELAWARE
Crab Chitin–*Utilization*

FLORIDA
Sea Squirt Extracts–*Anticancer Activity*
Immunosuppressants

GEORGIA

HAWAII
Ciguatoxin–*Detection in Marine Organisms*
Origin
Laboratory Simulation
Mechanism of Action

LOUISIANA

MAINE/NEW HAMPSHIRE CONSORTIUM

MARYLAND

MASSACHUSETTS
Chitin–*Industrial Applications*

MICHIGAN

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM
Algal Blooms–*Inhibiting Substances*

NEW JERSEY
Anticoagulant Drugs–*Animal Sources*
Evaluation
Chitosan–*Enzymatic Preparation*
Medical Uses

NEW YORK
Sponge Extracts–*As Antibiotics*
Industrial Enzymes–*Marine Sources*
Marine Weeds–*Potential Uses*

NORTH CAROLINA

OHIO

OKLAHOMA
Active Marine Compounds–*Extraction*
Screening
Testing

OREGON
Radioactive Extracts From Marine Invertebrates
Salmon Culture Antibiotic
Antitumor Cardiovascular and Neurotropic Activity
Marine Fungi–*Function and Importance in Marine Environments*

PENNSYLVANIA

RHODE ISLAND
Red Tide Toxins–*Isolation*
Characterization
Protection
Marine Pharmacology

SOUTH CAROLINA

TEXAS
Marine Pharmaceuticals–*Development*

VIRGINIA

WASHINGTON
Bioluminescent Substances–*As Blood Serum Calcium Detectors*
Marine Polymers–*Production*
Characterization
Utilization
Bivalves–*Byssus Studies*
Shellfish Exoskeletons–*Utilization*

WISCONSIN
Bioactive Substances–*Chemistry*
Pharmacology

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TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO

NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

Sea Grant Table VI

Sea Grant-Supported Minerals Projects

ALASKA

ARIZONA

CALIFORNIA
- Shelf Sand and Gravel Inventory
- Coastal Oil and Tar Seeps

CONNECTICUT

DELAWARE
- Delaware Bay Sedimentary Structures

FLORIDA

GEORGIA
- Submarsh Stratigraphy
- Coastal Aquifer–*Confining Strata*
- Sand and Gravel Deposits–*Evaluation*
- Undersea Mineral Exploration

HAWAII
- Coastal Sand Resource Survey
- Sand Recovery Systems
- Management Deposits–*Economic Potential*

LOUISIANA

MAINE/NEW HAMPSHIRE CONSORTIUM

MARYLAND

MASSACHUSETTS
- Offshore Petroleum
- Assay of Marine Resources

MICHIGAN

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM

NEW JERSEY

NEW YORK
- Sand and Gravel–*Great Lakes Survey*
  - *Assessment*
  - *Resource Management*

NORTH CAROLINA
- Sounds and Estuaries–*Erosion and Deposition*
- Estuarine Mineral Deposits
- Continental Shelf Mineral Deposits

OHIO

OKLAHOMA

OREGON

PENNSYLVANIA

RHODE ISLAND

SOUTH CAROLINA

TEXAS
- Galveston Island–*Sediment Budget*

VIRGINIA

WASHINGTON

WISCONSIN
- Noble Metals Exploration–*In Alaska*
- Lode Minerals Exploration–*Copper in Lake Superior*
- Manganese Nodules–*Lake Michigan*
- Sand and Gravel Assessment–*Lake Michigan*
- Power Plants–*Influence on Sediment Transport*

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NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

Socioeconomic and Legal Research

While Marine Resources Development projects address the science and technology of exploiting fisheries, minerals, and energy, Socioeconomic and Legal Research examines such questions as: What are the costs? Benefits? Are there cultural constraints or impacts? What are the controlling economic factors? Are there any special marketing problems? Potentials? What are the institutional, legal, and regulatory needs? The nature of the concern may be local, national or international —though the main emphasis is on the first. Table VII summarizes 1976 levels of activity under this category.

Research tasks supported under this category range from providing better informational and analytical bases for decision-making to development of "show-how" scenarios for opening up new markets for marine products. This requires not only sound bases, but also elaboration of the economic, legal, and social implications involved. In this way, Sea Grant is contributing to the evolution of new levels of discipline in public management processes.

Food from the sea draws considerable attention —both aquaculture and fisheries. In those States where it is new, aquaculture seldom fits neatly into existing administrative and regulatory structures. This may be a greater obstacle to a viable aquaculture industry than lack of technology. Sea Grant assistance in removing this obstacle ranges from identification of potential resource-use conflicts and how they might be mitigated to preparation of draft legislation to permit, encourage, and regulate aquaculture, and *pro forma* financial projections to encourage private investment in it. Such studies have been supported in Oregon, Washington, California, Louisiana, Florida, Rhode Island, Massachusetts, and Maine.

Socioeconomic and legal fisheries research projects may seek a better understanding of specific local fisheries, or they may tackle broad national and international problems. Thus, Rhode Island has produced several species-specific studies and also has published a fine little book on the social and cultural characteristics of commercial fishermen—an often ignored aspect of commercial fisheries management. New York seeks to understand and reverse the continuing historical decline of its commercial fisheries, while Texas is studying the economics of utilizing the tremendous tonnage of finfish thrown away by shrimpers. Florida has produced an analysis of the contribution of its commercial fisheries to the State's economy. It has also examined the politics and economics—both domestic and international —of its shrimp and spiny lobster fisheries, the last with special regard to the recent exclusion of Americans from the Bahama Banks fishery.

On a broader front, some 20 studies have been completed and others are underway on the meaning of extended jurisdiction to the fisheries and fishermen of the 23 seacoastal States. Because of these, when the President signed the 200-mile

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Sea Grant Table VII

Marine Socioeconomic and Legal Research
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget(1) ($-million)	Active Projects		Federal Funds		Matching Funds	
		Number	Average Cost Per Project ($)	($-million)	Per Cent of Total Federal Sea Grant(2)	($-million)	Per Cent of Total Program Budget(3)
Marine Economics	0.8	23	37,000	0.6	2.7	0.2	24
Ocean Law	0.7	17	41,000	0.4	1.7	0.3	44
Marine Recreation	0.1	6	21,000	0.1	0.5	0.04	32
Sociopolitical Studies	0.5	11	44,000	0.2	1.0	0.3	54
Category Totals	2.1	57	37,000	1.3	5.9	0.8	38

(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.

economic zone bill into law, many of the problems, needs, and opportunities of extended fisheries jurisdiction already had been identified. This is but one example of Sea Grant's ability to anticipate upcoming needs.

Many coastal States and the Federal Government are better able to cope with the expansion of oil and gas development to new parts of the Outer Continental Shelf because of 35 separate studies supported by Sea Grant in 14 different States. Similarly, Sea Grant has supported several studies of deepwater ports, including one, carried out at the request of the Council on Environmental Quality, which reported on the probable impacts of such facilities at 11 different coastal locations.

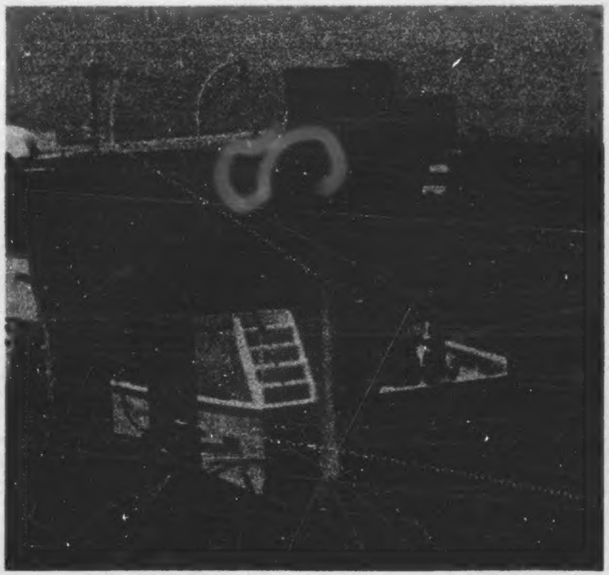
Virtually every Sea Grant State has one or more recreation-oriented projects. Coastal recreation is fraught with many dilemmas: opening a recreational resource to too many people might destroy the very environmental characteristics that draw them to it, for example.

The economics of coastal recreation have been examined from several perspectives. Both Florida and Rhode Island researchers, for example, have studied the noneconomic benefits of beach use and tried to develop monetary value schemes for rating individual beach experiments. Texas A&M has conducted a socioeconomic analysis of charter boat operators and consumers, while both Mississippi and New York have examined the economics of sport fishing. New York also has inventoried its Great Lakes marinas and surveyed their operators. Texas has classified its recreation areas, surveyed and projected recreation preferences, established a computerized recreational data bank with a predictive capability, inventoried recreation and tourism units in the costal zone, and computed the economic impact of coastal zone tourism on both the coastal zone and the State as a whole. Studies such as these are essential to sound coastal zone management—especially as more and more coastal resource use decisions come down to tough "either-or" judgments.

The range of activities under this category is wide and diversified, including in addition to the above: a comprehensive analysis and forecast of Great Lakes shipping; existing public rights in land and water resources; alternative offshore mineral leasing arrangements; methods and problems of public land acquisition; private vs. public provision and operation of recreational facilities; detailed compilations of existing State laws affecting marine activities; legal impediments to the use of interstate compacts in fisheries management; demographic characteristics of coastal populations; and the like.

In sharp contrast to studies such as these is the Law of the Sea Institute founded at the University of Rhode Island and now located at the University of Hawaii. Sea Grant-supported from the very beginning, its annual meetings and periodic workshops regularly bring together statesmen, politicians, and legal scholars from all over the world. These meetings and Institute publications have played a leading role in stimulating debate, increasing understanding, and encouraging evolution of common perceptions of the evolving new international Law of the Sea.

A summary of projects under this category by States can be found in Table VIII.



Wistful visitor watches pleasure boat sail from marina in Portsmouth, Virginia.

Sea Grant Table VIII

Sea Grant-Supported Socioeconomic and Legal Projects

ALASKA
- Law of the Sea–*Regional Application*

ARIZONA

CALIFORNIA
- Aquaculture–*Economics*
  - *Public Regulation*
- Limited Entry Fisheries–*Assessment*
- Public Policy–*Impact*

CONNECTICUT

DELAWARE
- Groundfish–*Forecasting Model*
- Coastal Industries–*Analysis*
- Seashore Recreation–*Sociology*

FLORIDA
- Seafood–*Fishing and Marketing Economics*
- Beaches—*Protective Ordinances*
- Community Legal Services
- Marine Recreation–*Assessment*
- Ocean Law Education

GEORGIA
- Fishing Harbors–*Economic Analysis*
- Shrimpers–*Occupational Analysis*
- Aquaculture–*Law*
- Coastal Zone Planning–*Mechanisms*

HAWAII
- Deep Sea Resources–*Response to Exploitation*
- Tuna Fisheries–*Development Analysis*
- Coastal Zone Management–*Methods*
  - *Planning*
  - *Legislation*

LOUISIANA
- Crawfish Processiing–*Economic Analysis*
- Port, Waterway and Pipeline Development
  - *Site Selection*
  - *Legal Aspects*
  - *Policy Aspects*
- Deepwater Port–*Environmental Analysis*
  - *Recreational Potentials*
- U.S. Policy Goals–*Alternative Methods*
- Estuarine Land–*Recreational Potential*
- Maritime Labor–*Instability*
- Coastal Resources–*Economics*
- Urban Encroachment

MAINE/NEW HAMPSHIRE CONSORTIUM
- Marine Industry, Recreation and Fishing–*Potential interactions*
- Socioeconomic and Legal Studies
- European Oysters–*Potential in U.S.*

MARYLAND

MASSACHUSETTS
- Georges Bank Fishery
- Extended Jurisdiction–*Technology Regulation*
- Sea Grant Technology–*Decision Processes*
- Ocean Management and Policy

MICHIGAN
- Fisheries–*Economics and Marketing*
- Water Resources–*Management*
  - *Economics*
- Recreation Behavior Patterns
- Environmental Decision Makers

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM
- Coastal Zone–*Legal Problems*
- Sport Fishing–*Demand and Supply Analysis*

NEW JERSEY

NEW YORK
- Coastal Law–*Problems*
- Coho Salmon–*Fishery and Community Impact*
- Coastal Recreation
- Supply of Rental Boats
- Marina Businesses and Users
- Siting Policy–*Present and Future*
- Ports–*Activities and Growth*

NORTH CAROLINA
- Fresh Seafood Marketing Channels
- Coastal Zone Management–*Legal Aspects*
- Resource Exploitation–*Legal Problems*

OHIO
- Seafood Distribution and Marketing–*Analysis*

OKLAHOMA

OREGON
- Seafood Markets–*Structure and Performance*
- Regional Law Development–*Ocean and Coastal*
- Extended Fisheries Jurisdiction–*Economics*
- Coastal Areas–*Economics*
- Industries and Public Policy
- Limited Entry–*Impact*

PENNSYLVANIA

RHODE ISLAND
- Marine-Oriented Activities–*Economics*
- Extended Fishery Jurisdiction–*Economic Impacts*
- Law of The Sea Institute
- Coastal Marina–*Ecological Impact*
- Narragansett Bay–*Economics and Ecology*
- New England Petroleum–*Assessment*
- Waste Disposal–*Economics*
- Clam Resources Management
- Fisheries–*Socioeconomics*

SOUTH CAROLINA
- Cooperative Hull Insurance–*Feasibility*

TEXAS
- Shrimp Industry–*Costs and Returns*
- Finfish Marketing Systems
- Ocean Law Changes–*Legal Implications*
- Charter Fishing–*Analysis*
- Recreation/Tourism–*Impact*
  Needs

VIRGINIA

WASHINGTON
- Puget Sound Recreational Fishery
- Commercial Fisheries–*Economics*
- Marine Environment of Puget Sound

WISCONSIN
- Cold Water Fish Aquaculture–*Economics*
- Great Lakes Fisheries–*Economics*
- Water Management–*Problems*
  Applications
- International Cooperation–*Institutions*
- Recreation–*Behavior and Attitude Patterns*

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- Marine Resources–*Exploitation*

TRUST TERRITORIES

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NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

Marine Technology Research and Development

While other Sea Grant programs help to find and define marine resources or establish their economic and legal parameters, Marine Technology Research and Development projects tackle the machinery and methods needed to exploit these resources, minimize their adverse environmental impact, conserve them, and control pollution associated with their use and taking. This is where engineers and technicians shine as they seek to improve ocean, coastal, and seafloor engineering; structures and materials; large floating platforms; artificial offshore islands; the human capability to work and play beneath the sea; commercial fishing gear and ships; aquaculture pens, ponds, and raceways; seafood handling, processing, storage, shipping, and display; underwater dredging and pipelining; coastal and marine recreational gear and facilities; and marine transportation including high-speed commuter systems, ports, harbors, and offshore terminals—just to mention a few. Table IX shows the 1976 level of activity under this category.

Hawaii, a growing island State of small land but vast ocean area, has designed, built, and sea-tested a large scale-model of a stable floating platform which one day may support large, self-contained ocean communities. It has reported on the technical and economic feasibility of high-speed interisland transport using hydrofoils, hovercraft, or both, and has examined the problems and potentials of linking the major islands with a centrally located thermal energy source via high-voltage undersea cables.

Florida and others are seeking better ways of controlling marine corrosion and fouling, while Wisconsin studies freshwater corrosion, especially where heavy pollution and stray currents are present—as is common around major Great Lakes ports. Wisconsin has researched and reported on technology's potential roles in Great Lakes waterborne trade. Both Wisconsin and Michigan are concerned with coastal erosion, while they and Alaska have problem-oriented projects in ice engineering.

Engineering studies of alternative deepwater port designs have been carried out by Delaware, Texas, and Louisiana. Aquaculture engineering research—including waste engineering—is underway in Alaska, Massachusetts, Texas, Wisconsin, Virginia, Hawaii, Florida, Delaware, and other States. Responding to the problems and perils of its bold exposure to the open ocean, Rhode Island Sea Grant has designed, built, and tested an effective, inexpensive "do-it-yourself" floating breakwater made of old automobile tires which is easily deployed and removed. Its use is spreading to other areas both in the United States and abroad. California also has designed and tested a floating breakwater composed of closely packed arrays of tethered spherical floats.

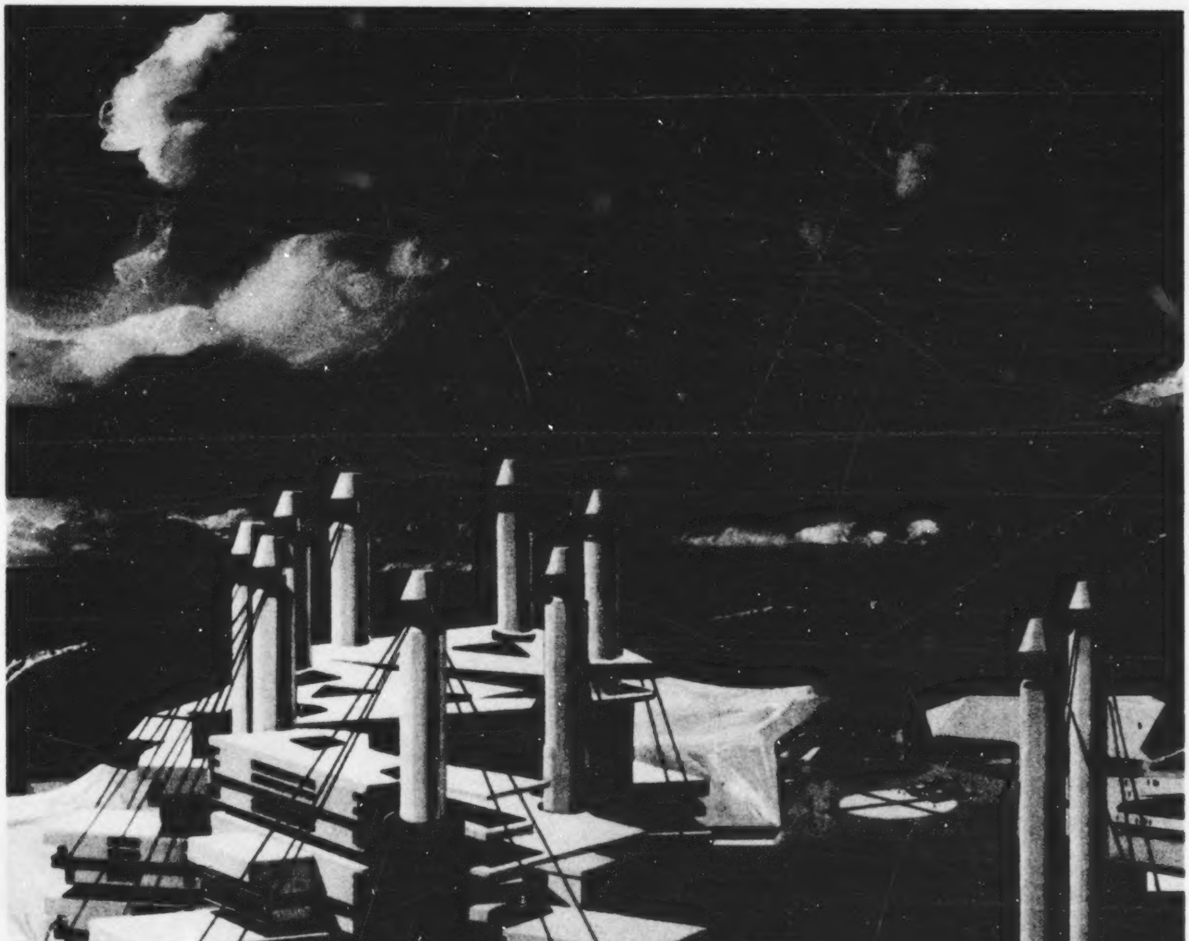
Humans-in-the-sea projects cover a wide range from underwater living and work experiments in Michigan and New Hampshire and computer modeling of thermodynamic concepts of decompression sickness in Texas, to development of diver standards and training programs in Florida, numerical models of forces on working divers at Michigan and Wisconsin and oil-field diver programs in Washington. Coastal structures and their

Sea Grant Table IX

Marine Technology Research and Development
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget(1) ($-million)	Active Projects: Number	Active Projects: Average Cost Per Project ($)	Federal Funds: ($-million)	Federal Funds: Per Cent of Total Federal Sea Grant(2)	Matching Funds: ($-million)	Matching Funds: Per Cent of Total Program Sea Grant(3)
Ocean Engineering	2.2	56	39,000	1.3	5.6	0.9	40
Resource Recovery and Utilization	2.1	58	36,000	1.3	5.6	0.8	38
Transportation Systems	0.1	4	27,000	0.07	0.3	0.04	33
Category Totals	4.4	118	37,000	2.7	11.5	1.7	39

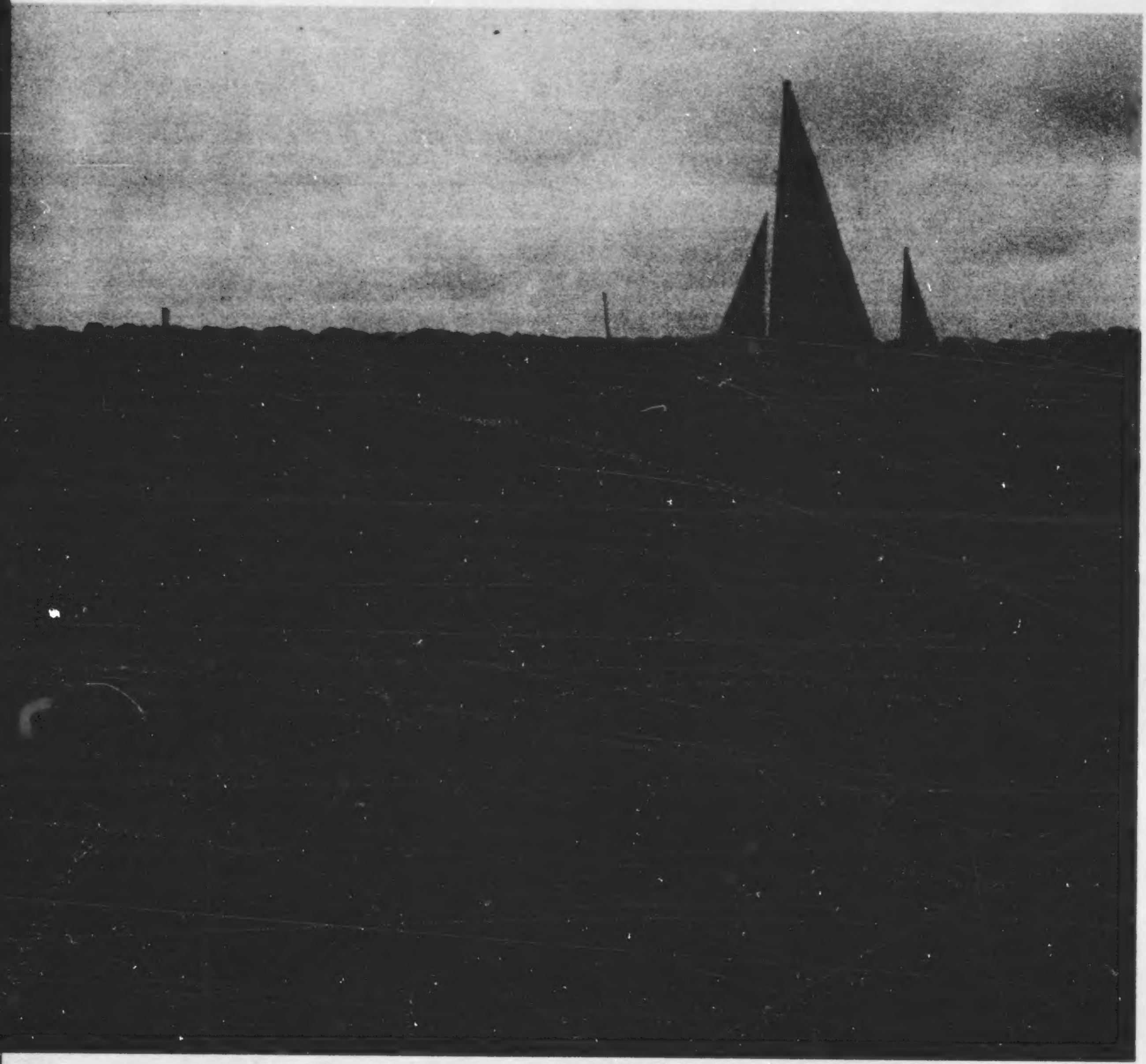
(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.



Artist's concept of a floating city.

responses to water forces are being studied at Hawaii, Oregon, California, and Wisconsin, while Florida has produced a very practical report on how to build hurricane-proof structures. North Carolina, South Carolina, Virginia, and Florida are trying to improve beach stabilization technology, while Oregon has developed a technique for greatly extending the life of wooden pilings in the marine environment. Massachusetts Sea Grant has shown that high-energy electron beams can kill harmful bacteria and break down complex organic compounds in sewage and other waste water. New York has developed two methods which show promise in removing mercury from fish, while a continent away, in Oregon, a specially adapted seismograph has proved its worth as a remote sensor measuring sea states over the bars found before the entrances to most harbors along that coast.

There are many more projects under this category, both past and present. For a more complete summary, see Table X.



Floating tire breakwater.

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Sea Grant Table X

Sea Grant-Supported Technology Research and Development Projects

ALASKA
- Sub-Bottom Arctic Structure
- Sea Ice–*Dynamics*
- Aquaculture Development
- Permafrost–*Characteristics, Distribution*
- Marine Organisms–*Heavy Metals Concentration*
- Use of Marine Mammals
- Harbor Seals–*Biology*

ARIZONA

CALIFORNIA
- Salinity Gradients–*Power Source*
- Concrete Construction–*Electrical Hazards*
- Wave Climate Modifications
- Diving Safety Program
- Hake Fishery Development
- Fish Products–*Histamine Toxicity*
- Seafood Technology
- Fishery Products–*Quality Assessment*
- Black Cod Fishery–*Improved Methods*
- Breakwater Modifications–*Reducing Harbor Surge*
- Ocean Construction–*Composite Materials*

CONNECTICUT

DELAWARE
- Beach Erosion–*Assessment*
  Control
- Closed Cycle Mariculture
- Closed Cycle Systems–*Chemistry*
- Mariculture–*Development Service*
- Mariculture–*Water Recycling*

FLORIDA
- Metal Corrosion–*Bridge Pier Cracking*
- Canal and Lake Flushing–*Hydrodynamics*
- Florida Sand Budget
- Oil Spills–*Magnetic Recovery*
- Fishing Gear Design–*Modeling*
- Mullet–*Controlling Rancidity*

GEORGIA
- Finfish Fishery–*Feasibility*
- Fisheries–*Processing and Maximum Utilization*
- Shrimp Meal–*Nutrient Quality*
- Chitosan–*Production, Utilization*
- Shellfish Processing
- Fish and Shrimp Byproducts
- Fish Smoking Processes

HAWAII
- Deep Ocean Cosmic Ray Interactions
- Seaward Advancement
- Undersea Observation Structure
- Heat Exchanger–*Biofouling Experiment*
- Pipelines–*Wave Attack*
- Waves–*Reef Attenuation and Set-Up*
- Tropical Aquaculture
- Human Performance in The Sea
- Decompression Safety
- Floating Platforms–*Feasibility*
- Sealed Concrete–*Additional Strength*
- Rapid Transit–*Marine Alternatives*

LOUISIANA
- Antifouling Materials
- Cable Insulation–*Materials*
- Seafood–*Quality Control*
- Superports and Offshore Facilities–*Planning*
- Fisheries–*Product Development*

MAINE/NEW HAMPSHIRE CONSORTIUM
- Beach Systems–*Management Options*
- Acoustic Surveying–*Parabolic Reflectors*
- Dynamic Floating Breakwater
- Diver Telemetry–*Physiological Data*
- Fishery Byproducts–*In Animal Food*

MARYLAND
- Soft Shell Clams–*Viability After Being Caught*

MASSACHUSETTS
- Foundation Design–*In Marine Soils*
- Offshore Structures–*Analysis*
- Undersea Work–*Teleoperators*
- Deepsea Joining, Cutting–*Techniques*
- Ocean Wave Energy System
- Trawl Board Improvement
- Side Trawl Hookup Block–*Improvement*
- Dogfish (shark)–*Skinning Process*
- Fisheries Products–*Lipid Compounds*
- Seafood–*Pressure Preservation*
- Current Sensor–*Dynamics*
- Water Treatment–*High-Energy Electron Beam*

MICHIGAN
- Fishing Gear Improvement–*Purse Seining*
- Diving Safety–*Research and Recreation*

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM
- Raw Oysters–*Enterovirus Detection*
- Isoelectric Focusing–*Applications*
- Remote Underwater Fishery Assessment
- Underwater Reconnaissance Vehicle

NEW JERSEY

NEW YORK
- Submerged Vegetation–*Sediment Stabilization*
- Dredge Spoil Disposal
- Underutilized Species–*Convenience Products*
- Clam Wash Water–*Utilization*

Fish Product Quality–*Lipids*
Fish Filleting–*Waste Recovery*
Industrial Fish–*Mercury Removal*

NORTH CAROLINA
Seafoods–*Microconstituents*
Crabmeat Processing–*Quality*
Seafood–*Pathogen Controls*
Fish Muscle Tissue–*Properties*
Marine Structures–*Reliability*
Beach Control–*New Method*

OHIO

OKLAHOMA

OREGON
Structure Design–*Wave Simulation*
Wooden Structures and Boats–*Improvements*
Crabs–*Laser and Freeze Branding*
Fishing Gear–*Development*
Wooden Pilings–*Preserve by Fumigation*
Seafood–*Processing Sanitation*
Utilization
Mechanization
Nutritional Quality
Quality Control
Shellfish Waste–*Agricultural Use*
Tuna–*Safety Test*
Sewage Discharge–*Reduced Damage*
Bar Clearance Sensor–*Remote Seismometer*

PENNSYLVANIA

RHODE ISLAND
Metal Reinforced Concrete–*Degradation*
Hard-Bottom Combination Net
Fatal Scuba Accidents–*Analysis*
Crab Waste Use–*In Salmonid Aquaculture*
Assessing Seafood Quality
Bay Watch–*Engineering Services*
Scrap Tire Floating Breakwater
Fishing Gear– *Hydrodynamics*
Improvement

SOUTH CAROLINA
Marine Turtles–*Inventory*
Shrimp Heads–*Automatic Removal*
Diked Disposal Areas–*Utilization*
Aquaculture Mechanization

TEXAS
Offshore Pipelines–*Engineering*
Coastal Processes–*Numerical Models*
Dredge Disposal–*Trace Elements*
Dredge Spoil Islands–*Erosion*
Saturation Diving–*Maximum Depths*
Hydrogen/Oxygen Decompression Tables
Seafood–*Safety and Wholesomeness*
Intracostal Waterway–*Environmental Impact*
Offshore Terminals–*Impact on Industry*
Fishery Products–*Sanitation; Quality Control*

VIRGINIA
Protective Structures–*Engineering*

WASHINGTON
Fishing Vessel Safety
Floating Breakwater Research
Fish Stocks–*Acoustic Counting*
Marine Acoustics
Total Utilization Concept
Chitin/Chitosan–*Potential Utilization*
Floating Structures–*Performance Tests*

WISCONSIN
Corrosion–*Fresh (Polluted) Water*
Underwater Welding–*Steel*
Harbor Flushing Measurements
Marinas–*Lake Ice*
Harbor/Offshore Water Exchange
Fish Production Wastewater–*Treatment*
Underutilized Fish –*Product Development*
Quality Improvements
Divers–*Artificial Gills*
Diver Orientation Devices
Other Diver Aids
Physiological Evaluation
Great Lakes Water Transport
Controlled Homing–*Odor Imprinting Salmon*
St. Lawrence Seaway–*Modeling*
Predicting Water Closing

DISTRICT OF COLUMBIA

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TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO
Underwater Habitats–
Potential for Resource Management

NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

Marine Environmental Research

The foundation of management is knowledge. When Sea Grant came into being comparatively little information existed on the natural resources to be managed, and much that did exist was unuseable because of its form and the narrow purposes (usually scientific) for which it was developed originally. Demographic and other information on human activities was in pretty good shape, but how the human system and the natural system interacted was only imprecisely known, the subject of frequent adversary confrontations, and totally inadequate for management purposes.

The purpose of Sea Grant-supported Marine Environmental Research is to try to fill these gaps—to gather data in a consistent and disciplined manner and to define system interactions in terms which are meaningful to management and can be subjected to computer analysis and testing. The ultimate objective is to make reliable predictive analysis a standard management tool. This offers the academic community an exciting opportunity to strengthen intellectual excellence while greatly expanding public service capabilities. To the individual States, this research offers the opportunity to obtain a valuable adjunct of the governing process at a quite low cost. In the 13 Sea Grant College States—namely, Rhode Island, Massachusetts, New York, Delaware, North Carolina, Florida, Wisconsin, Texas, California, Oregon, Washington, Louisiana and Hawaii—this goal has been realized. Other States show varying degrees of progress. Table XI shows the level of activity under this category.

In general, Sea Grant-supported projects under this category address the following types of activities:

- Baseline and inventory studies of coastal and marine areas and their resources and environmental features, including, quite frequently, the incorporation of these data into published atlases of the physical, chemical, biological, and other characteristics of relevant bodies of water.
- Development of specific use-related baseline data banks—including, where appropriate, evaluation of future impacts of decisional alternatives—hitting such issues as power plant siting, public shoreline access, pollution control, conflicting resource uses, dredge spoil disposal, and sewage outfalls.

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- Study of important environmental processes, such as nutrient flow through estuaries and marshes, coastal erosion, littoral transport, subaerial dune erosion, and the scouring and sedimentation in harbors, bays, and channels.
- Interactions within the environment, such as faunal and floral responses to changes in nutrient balance, temperature, dissolved oxygen, and light.
- Studies of pollution sources, pathways, residence times, and fates—including heat, radionuclides, mercury, and other heavy metals, petroleum, polychlorinated hydrocarbons (DDT, PCB's, etc.), and other municipal, industrial, and agricultural wastes.
- System studies of major coastal and estuarine features such as Puget Sound, Green Bay, Grand Traverse Bay, Saginaw Bay, Houston Ship Channel, Biscayne Bay, Santee Estuary, Pamlico Sound, Albermarle Sound, Chesapeake Bay, Delaware Bay, Long Island Sound, Narragansett Bay, Massachusetts Bay, and a 50-mile stretch of Massachusetts, New Hampshire, and Maine coastline.
- Development of numerical models for computer analysis and prediction of natural systems, human activities, economic systems, and their interactions.
- Search for ways to detect, measure and remove pollutants, to reverse human-caused environmental damage and to convert wastes into harmless or profitable products.
- To provide data bases and analyses in specific support of legislative, regulatory and permitting activities of local, State, and Federal governments.

The nature of individual projects varies widely, according to the most pressing needs of each part of the country. Louisiana Sea Grant has participated in the environmental assessment of the whole LOOP (Louisiana Offshore Oil Port) project, including offshore facilities, tank farm, and pipeline right-of-way, while Texas A&M scientists have produced a significant four-volume report on "Water Quality Characteristics of Hazardous Materials" and determined the feasibility of aerating the Houston Ship Channel.

Rhode Island Sea Grant researchers have constructed an elaborate series of interlocking computer models of Narragansett Bay which are now used to support State coastal zone management efforts; it also has developed an infrared technique for identifying pollutants. New Hampshire researchers are studying the long-term environmental effects of dumping baled solid wastes into the ocean. Wisconsin Sea Grant investigators are studying the environmental preferences of coho salmon by means of telemetry devices attached to the fish; they are monitoring and researching a wide range of pollutants common to the Great Lakes; and they are exploring the effects on primates (of which humans are one species) of chronic exposure to PCB's.

Sea Grant Table XI

Marine Environmental Research
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget(1) ($-million)	Active Projects		Federal Funds		Matching Funds	
		Number	Average Cost Per Project ($)	($-million)	Per Cent of Total Federal Sea Grant(2)	($-million)	Per Cent of Total Program Budget(3)
Research In Support of Coastal Zone Management	2.2	68	33,000	1.4	5.8	0.9	39
Ecosystems Research	0.9	32	28,000	0.5	2.2	0.4	42
Pollution Studies	1.5	47	32,000	1.0	4.1	0.5	36
Environmental Models	1.2	22	53,000	0.7	2.9	0.5	41
Applied Oceanography	0.5	11	43,000	0.3	1.2	0.2	41
Category Totals	6.3	180	35,000	3.8	16.3	2.4	39

(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.

Pollution.

53

Both California and Washington Sea Grant scientists are looking at the ecological effects of large sewage outfalls discharging into large bays and the open ocean. Hawaii researchers are studying the effects of pollutants on the larvae of important species of fish, e.g., tuna. The Mississippi program has developed techniques for converting raw seafood wastes into fish farming rations and for using electrolysis to purify waste water. Maine investigators have studied the effects on baitworms of thermal discharges from electric power plants, while Florida scientists have looked at the impact of thermal and radioactive pollution on shrimp and other important marine species.

And so it goes. Responses to local needs and opportunities are what determine the makeup of Sea Grant projects at any given point in time. Table XII provides a more complex summary of activities under this category.

Sea Grant Table XII

Sea Grant-Supported Environmental Research
(1967–1976)

ALASKA
- Resurrection Bay–*Hydrography, Chemistry*
- Marine Planning–*Education*
- Prudhoe Bay–*Primary Production*

ARIZONA

CALIFORNIA
- Coastal Governance–*Issues*
- Coastal Development–*Management*
- Coastal Planning–*Methods*
- San Francisco Bay–*Biology*
- Sea Urchins Fisheries–*Assessment*
- Beaches and Dunes–*Vegetation*
- Nutrient Quality–*Enhancement*
- Food Resources–*Dynamics*
- Plankton–*Inshore Food Source*
- Kelp Grass–*Metabolism*
- Waste Heat Effluents–*Effects*
- Stress Induced Fish Parasitism
- Chemical Pollution–*Bioassay*
- Microbial Pollutants–*Analysis*
- Fish Population–*Pollution Effects*
- Coastal Planning–*Criteria*

CONNECTICUT
- Heavy Metals–*Oyster Uptake*
- Heavy Metals–*Circulating, Distribution, and Concentration*
- Long Island Sound–*Circulation Patterns*
- Connecticut River Plume

DELAWARE
- Wave Damage–*Prediction*
- Coastal Development–*Impact*
- Trace Metals–*In Shellfish*
- Estuaries–*Nutrients, Energy, Production*
- Barriers–*Structure, Evolution, Destruction*
- Wetlands Vegetation

FLORIDA
- Estuarine Environmental Study
- Productivity–*Energy Flows and Patterns*
- Pesticides–*Effect on Fisheries*
- Sewage Pollution Abatement–*Impact*
- Circulation and Dispersion–*Modeling*
- Shoreline Evolution
- Thermal Pollution–*Hearings*
- Coastal Exchange Processes

GEORGIA
- Oceanographic Atlas Series
- Marsh Condition Index
- Estuarine Hydrography–*Data Compilation*
- Estuarine Environments–*Subtidal*

HAWAII
- Reef Fish–*Commercial Exploitation*
- Legislative Assistance–*Environmental*
- Coastal Decision–*Baseline Data*
- Coral Reef Management
- Oceanic Pathogens–*Viruses*
- Extreme Wave Conditions–*Statistics*

LOUISIANA
- Marsh Recreational Dwellings
- Coastal Resources–*Analysis*
- Marine-Fresh Water Exchange
- Primary Productivity–*Offshore*
- Metropolitan Metabolism–*Coastal*
- Wetlands–*Soil-Nitrogen Transformation*
- Spartina/Cellulose Transformation
- Cypress Swamp–*Chemical Ecology*
- Shellfish–*Hydrocarbon Content*
- Hydrocarbon–*Estuarine Carbon Flux*
  - Food Chain Concentration
- Water and Sediment–*Chemistry*
- Marsh-Estuarine System–*Models*

MAINE/NEW HAMPSHIRE CONSORTIUM
- Land Use Planning
- Reactor Radionuclides–*In Oysters and Sediments*

Marine Worms–*Thermal Pollution Effects*
Hydrodynamic and Environmental Modeling
Estuarine Nutrients–*Distribution*
Oil Slicks–*Remote Sensing*

MARYLAND

MASSACHUSETTS
Fluviatile Salmonids–*Interactions*
Oil Slick Control
Bedford Harbor–*Sediment Dispersal*
Water Movement and Dispersion–*Models*
Sediment Transport–*Longshore*
Inlet Stability
Red Tides–*Trace Metals Role*

MICHIGAN
Shoreline Protection–*Private*
Erosion Damage–*Analysis*
Coastal Zone Engineering
Fisheries–*Great Lakes*
Shorelands–*Planning and Management*
Lake Currents–*Modeling*
Sewage Treatment–*Technology*
Water Quality–*Regional Survey*
Phytoplankton–*Nutrient Enrichment*

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM
Marshes–*Management Planning*
Coastal Zone Capability–*Analysis*
Seafood Wastes–*Marketable Commodities*
Shrimp Processing–*Waste Treatment*
Mobile Bay–*Physical Environment*
Gulf Coast–*Environmental Simulation*

NEW JERSEY
Heavy Metals and Nutrients–*Distribution*
Metal Pollutants–*Biological Effects*
Mercury–*Biomagnification*
Coastal Waters–*Numerical Simulation*
Plankton–*Physiochemical Ecology*
Pollutant Transport Patterns–
By Sulfate Chlorinity
Newark Bay–*Renewal Rate*

NEW YORK
Coastal Management–*Institutions, Public Participation*
Coastal Waters–*Management*
Lake Ontario–*Environmental Atlas*
Erosion/Deposition–*Balance*
Coastal Zone–*Visual Quality*
Recreation
Power Plant Siting
Seafood Processing Effluents–*Ultrafiltration*
Plankton–*Pollution Effects*
Viruses–*Surf/Atmosphere Transfer*

NORTH CAROLINA
Coastal Management–*Ecological Determinants*
Dredge Spoil–*Marsh Regeneration*
Shore Environments–*Classification*
Coastal Birds–*Populations*
Dune Stabilization
Shellfish Viruses–*Detection*
Onslow Bay–*Physical Studies*
Beach Grass–*Destruction By Insects*
Pest Control Analysis
Pamlico Sound–*Numerical Model*

OHIO

OKLAHOMA

OREGON
Public Boating–*Space Demands*
Sea Lions–*Assessment*
Marinas–*Hydraulic Characteristics*
Clam Populations–*Subtidal*
Estuarine Plankton–*Dynamics*
Spit Erosion

PENNSYLVANIA

RHODE ISLAND
Coastal Resources Center
Menhaden/Sport Fish–*Relationships*
Erosion Inventory–*Photogrammetry*
Coastal Ecosystem Model
Phytoplankton Blooms–*Causes*
Bottom Community–*Carbon Flux*
Hydrocarbons–*In Sediments*
In Seawater
Coastal Areas–*Analytical Modeling*
Hydrodynamics/Salinity/Temperature–*Model*
Estuarine Deposits–*Three-dimensional Study*

SOUTH CAROLINA
Coastal Erosion–*Inventory*
Dredge Spoil–*Pest Management*

TEXAS
Resource Management
Channel-Harbor Complex–*Environmental Management*
Industrial Wastes–*Ocean Dumping*
Water Quality–*Artificial Aeration*
Estuaries and Shellfish–*Virus Enumeration*
Coastal Canals–*Water Quality*
Bromine Chloride–*Toxicity*
Bulk Shipping–*Hazard Rating System*
Oil and Tar Deposits
Coastal Engineering Research

VIRGINIA
Wetlands Management–*Alternatives*
Wave Refraction–*Synthesis*
Continental Shelf Bathymetry

WASHINGTON
Coastal Resources–*Governance*
  Methods
  Advisory Services
Ports–*Development and Operations*
Puget Sound–*Environment*
  Data Analysis, Applications
  Fish Ecology
  Resource Management
Resources–*Total System Approach*

WISCONSIN
Watershed Phosphorus–*Policy Implications*
Power Plant Siting
Coastal Resources–*Cultural and Historic*
Land Interest Information–*Coastal*
Shoreline Erosions–*Lake Michigan*
Plant Communities–*Coastal*
Coastal Slumps–*Mechanics*
Shoreline Mapping–*Computerized*
Coastal Zone–*Remote Sensing*
Shrimp–*Population Dynamics*
Deep-Living Phytoplankton
Fish–*Energy Requirements, Growth*
Fish Populations–*Acoustic Estimating Methods*
Pesticides–*In Food Chains*
Salmonids–*Microcontaminants*
Thermal Effluents–*Dispersion, Effects*
Trace Metals–*Transport and Distribution*
Paper Mill Effluent–*Toxicity*
Lake Trout–*PCB Effects*
Air Pollution Input–*Lake Michigan*
Salmonids–*PCB Metabolism*
Surface Microlayer–*Microcontaminants*
  Infractions
Organic Microcontaminants–*Analysis*
Primates–*PCB Response*
Fish Control Model
Salmon Management–*Odor Imprinting*

DISTRICT OF COLUMBIA

AMERICAN SAMOA

GUAM
Tumon Bay–*Bathymetry*
Coastal Zone–*Ecology*

TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO

NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

Marine Education and Training

New imperatives of coastal and marine resource exploitation and management require people with new capabilities. Ten years ago, there were virtually no programs offering the necessary educational opportunities. Sea Grant's Marine Education and Training initiatives soon remedied that, and in the 1972–76 period alone some 1,500 ocean engineers, more than 4,000 technicians, and 300 lawyers, marine economists, and marine affairs specialists graduated from Sea Grant-supported educational programs. In the spring of 1976 these programs had 761 graduate students and 291 technician trainees, of whom 127 were in fisheries-related programs. This category's 1976 level of activity is shown in Table XIII.

Sea Grant's mission is not to support educational programs indefinitely. Its mission is to provide financial help in starting a program for which there is a clear need. The primary criterion of need is the employability of graduates. Sea Grant's role is to assist university administrations to undertake new programs. It is assumed that, if there is a student demand and if its graduates are advantageously employed because of that education, the program will become self-supporting. Thus, the proportion of Sea Grant support begins diminishing from the beginning and eventually ends. If preprogram estimates of demand for the skills thus provided prove to be erroneous or if the market for that skill becomes saturated, Sea Grant support is terminated forthwith. Whereas Sea Grant once supported 20 different technician training programs, by 1976 that number was down to 15.

As a result of rigorous controls, the record of employment of graduates of Sea Grant-supported programs is excellent. Many run 100 percent consistently year after year. For the life of Sea Grant, the average for all programs is more than 80 percent. Many in the unemployed 20 percent choose to go on to higher degrees, while others pursue new careers.

Sea Grant Education and Training has three

Sea Grant Table XIII

Marine Education and Training
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget(1) ($-million)	Active Projects		Federal Funds		Matching Funds	
		Number	Average Cost Per Project ($)	($-million)	Per Cent of Total Federal Sea Grant(2)	($-million)	Per Cent of Total Program Budget(3)
College Level	0.8	31	27,000	0.3	1.2	0.5	65
Vocational	1.1	17	67,000	0.3	1.3	0.8	74
Retraining	---	--	-----	---	---	---	--
Other Education	2.2	37	59,000	1.4	5.9	0.8	37
Category Totals	4.2	85	49,000	2.0	8.4	2.2	53

(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.

basic objectives: (1) To train specialists such as commercial divers, boat and ship handlers, commercial fishermen, marine and oceanographic technicians, natural resources agents, marine veterinarians, ocean and coastal engineers, and aquaculturists; (2) to produce interdisciplinary, mission-oriented professionals to fill the demand for coastal zone managers, marine resource economists, environmental and economic impact analysts, and others who can understand and correlate different scientific and engineering disciplines as well as a wide range of human activities for systems management purposes; and (3) to create a better public understanding and appreciation of the oceans, their challenges, and their opportunities.

The need for educational programs such as these has catalyzed exciting changes within the participating universities. The need to develop and administer interdisciplinary and interdepartmental degree programs has exposed faculty and administrators alike to whole new perspectives of the roles and techniques of higher education. It also has provided the conceptual base and administrative machinery for the Sea Grant multi-capability, team approach to problem solving. In turn, the experience of such team members in the realities, complexities, deadlines, and requirements for *useable* results gives them new perceptions and knowledge for use in the classroom and, indeed, frequently suggests new courses and degree programs. The Sea Grant closed-loop feedback process benefits the whole system. There is also an indirect but worthwhile payoff in the greater prestige and visibility the university enjoys in its community.

Sea Grant Education and Training projects include everything from single courses and summer programs to two-year, four-year and graduate degree programs (See Tables XIV and XV). Among the earliest were the introduction of fisheries technology programs at Oregon State University, an undergraduate degree in Ocean Engineering at Florida Atlantic University, the Master of Marine Affairs (MMA) program at Rhode Island, and the Master of Laws in ocean law at the University of Miami. During its first few years, Sea Grant also supported ocean technician programs at Cape Fear Technical Institute, North Carolina, and the Southern Maine Regional Vocational Institute. Support for the last two institutions was halted when the demand for ocean technicians failed to justify further support.

Graduate student at the University of Wisconsin prepares for an experiment.

The MMA program at the University of Rhode Island in a way served as a prototype to the interdisciplinary approach to graduate education. Core courses were drawn from the Geography, Oceanography, Economics, and Engineering Departments, while electives could be taken in all departments. Many of the course offerings were new to URI—e.g., Marine Geography, Marine Resource Economics, Ocean Engineering, International Law. The purpose of the program was to expose administrators and policymakers to the problems of science and engineering in the ocean, of ocean law, and of marine operations generally; and to expose ocean scientists and engineers and, as it turned out, Naval officers to the politics and economics of marine affairs. The objective was to begin the process of providing the international negotiators, coastal zone managers, Federal and State administrators, and business executives who would be needed to manage America's coastal and contiguous marine resources and protect her interests world-wide.

Sea Grant Table XIV

Sea Grant-Supported Education and Training Projects

ALASKA
- Fishing Technology
- Seafood Processing
- Sea Grant Lecture Program
- Marine Science Public Television

ARIZONA

CALIFORNIA
- Commercial Diver Training
- Sea Grant Interns
- Coastal Decision-Making
- Marine Education Curriculum
- Marine Resource Management
- Technology Assessment Training

CONNECTICUT

DELAWARE
- Marine Education–*Public Schools*
- Marine Environment Studies
- Fisheries–*Management Economics*

FLORIDA
- Ocean and Coastal Law
- Underwater Technician
- Marine Technology Program
- 4-H Marine Program

GEORGIA
- Marine Resource Education

HAWAII
- Oceanographic Technician Training
- Cruise Experience–*Secondary Students*
- Marine Option Program
- Aquarium Operations
- Marine Education Exposition
- Marine Technology–*Teacher Training*
- Marine Curriculum–*Secondary Schools*
  - *Elementary Schools*
- Marine Pathology Courses

LOUISIANA
- Nautical Mathematics Textbook
- Nautical Science–*Vocational Program*
- Transportation Systems Modeling
- High School Teachers–*Marine Training*

MAINE/NEW HAMPSHIRE CONSORTIUM
- Aquaculture–*Graduate Study*
- Ocean Projects–*Undergraduate*
- Marine Technicians Training
- Marine Training–*For Teachers*

MARYLAND

MASSACHUSETTS
- Ocean Engineering–*Curricula*
  - *Laboratory*
  - *Textbook*
- Commercial Fisheries Program
- Deep Submersibles–*Launch/Retrieval*
- Stable Ocean Platforms
- Multidisciplinary Products–*Marine Sciences*
  - *Coastal Management*
  - *Systems Design*

MICHIGAN
- Underwater Technology Education
- Commercial Divers–*Operating Standards*

MINNESOTA

MISSISSIPPI/ALABAMA CONSORTIUM
- Marine Law and Science

NEW JERSEY

NEW YORK
- Coastal Law Traineeships
- Sea Grant Traineeships
- Public Service Legislation
- Engineering and Marine Technology
- Marine Industries Studies

NORTH CAROLINA
- Coastal Law
- Public School Marine Program–*Teacher Training*
  - *Teaching Materials*
  - *Teaching Guides*

Some programs, not necessarily degree oriented, are quite innovative, serve the interdisciplinary educational need, and produce a valuable service. Massachusetts Institute of Technology, for example, has since 1973 teamed up lawyers and engineers to tackle a variety of vital current marine issues. They have learned about and from each other and to work together as an interdisciplinary team with a single objective. This program has produced a series of research reports on such topics as offshore oil and gas, offshore nuclear power, maritime traffic control, ocean mining, and deepwater ports.

Technical and vocational training programs are mission-oriented and market-dependent. These determinations are made locally by the Sea Grant Director. Projects may upgrade existing skills or fill the demand for quite new ones. To its seamanship and navigation training, for example, Texas Sea Grant has added marine firefighting. With an eye on the completion of the Alaska pipeline, the University of Washington instituted a program in petroleum transportation and handling. Cape Fear Technical Institute (CFTI) serves as a regional training center for schools throughout North Carolina which offer marine programs but have no access to the sea or ships. CFTI ships and students regularly participate in major oceanographic expeditions.

Programs offered under Sea Grant auspices run the gamut, including coastal and marine recreation, wildlife management, marine law

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OHIO

OKLAHOMA

OREGON
Marine/Maritime Studies
Ocean Law Training
Marine Resources Management
Commercial Fisheries–*Technician*
Marine Technician Program
Seafood Technology

PENNSYLVANIA

RHODE ISLAND
Master of Marine Affairs
Marine Resource Economics
Ocean Engineering
Fisheries and Marine Technology

SOUTH CAROLINA

TEXAS
Ocean Engineering Programs
Crustal Evolutions–*High School*
Oceanic and Marine Technology
Marine Recreation Specialization
Marine Teacher Certification
Seminars–*Coastal Management*
Aquatic Animal Health
Marine Resource Management
Marine Diving Training

VIRGINIA

WASHINGTON
Marine Resource Economics
Coastal and International Ocean Law
Fisheries Education
Ocean Systems Design
Underseas Technician Program
Marine Science Technician
Fish and Game Technology
Commercial Fishermen's Education
Petroleum Technician Program
Curricula Development–*Interdisciplinary*
Seafood Technology
Marine Affairs Seminar
Advisory Service Educational Projects

WISCONSIN
Problems in Oceanography
Great Lakes–*Natural History*
Basic Scuba Diving
Maritime Transportation
Marine Communications Program

DISTRICT OF COLUMBIA
Ocean Engineering
Marine Technology Training
Fisheries Scholarship

AMERICAN SAMOA
Commercial Fisheries Development

GUAM
Manpower Survey–*Marine-Related*

TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO

NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

enforcement, commercial fishing, commercial diving, recreational diving, small boat and ship handling, navigation and command, marine electronics and mechanics, seafood technology, and others. The employment rate is very high, with many employers specifically seeking participants in these programs. Many graduates are self-employed, particularly fishermen and charter boat operators.

Many Sea Grant institutions offer programs directed specifically to primary and secondary school teachers who want to be able to expose their students to coastal and marine subject-matter. In most of these cases, the Sea Grant institution also develops course materials.

The State University System of New York offers programs in coastal law, coastal zone management for local government officials, marine business management for industry, and marine transportation and communications. Course formats vary from regularly scheduled classes at institutions of higher learning to traveling seminars that take the courses to the students—whichever best suits the needs of the participants.

Sea Grant has not solved all the manpower needs of coastal and marine resources management, but it has made a major contribution.

While much of the early educational emphasis in Sea Grant centered on technical and professional training, the fundamental necessity of creating a better public understanding about the oceans has not been overlooked. Working with

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Sea Grant Table XV

Courses Funded by Sea Grant
(As of July 1, 1975)

STATE	COURSE	INSTITUTION
ALASKA	Aquatic Science and Engineering Program	U. of Alaska
	Marine Technology Program	Kodiak C.C.
CALIFORNIA	Coastal Environmental Managerial Institute	U. of Southern California
	Marine Technician Training Program	Santa Barbara City College
	Practical Oceanography for Undergraduates	U. of California, San Diego
	Transactional Planning Seminar for Coastal Zone Decision-Makers	U. of Southern California
	Sea Grant Scholars Program	U. of Southern California
	Educational Training Assignments and Technology Assessments Program	Stanford U.
	Sea Grant Trainees and Intern Program	U. of California
DELAWARE	Marine Education	U. of Delaware
FLORIDA	Economics of Living Resources	Florida State U.
	Juris Doctor Specialization in Ocean and Coastal Law	U. of Miami
GEORGIA	Marine Resource Education	U. of Georgia
HAWAII	Marine Technician Training Program	Leeward C.C.
	Marine and Freshwater Aquaria II: Public Education and Public Involvement	U. of Hawaii
	Marine Option Program	U. of Hawaii
	Blue-Water Marine Laboratory	U. of Hawaii
	Planning for Coordinated Kindergarten-through-High School Marine Education Program	U. of Hawaii
LOUISIANA	Nautical Sciences Vocational Training	Louisiana State U.
	Marine Sciences Education	Louisiana State U.

the colleges and universities in the system, Sea Grant has made major strides in introducing oceanic studies to elementary and high schools in the Nation and in providing marine-related courses to adults. The Sea Grant educational effort has been one of rapidly expanding activities in the program.

Sea Grant recognizes the significance of developing greater oceanic educational opportunities for all Americans and is hopeful that it can bring a wider introduction of oceanic studies to school systems throughout the United States.

Sea Grant Table XV—2

MAINE/NEW HAMPSHIRE CONSORTIUM	Graduate Course in Aquaculture	U. of Maine
	Undergraduate Ocean Projects Course	U. of New Hampshire
MASSACHUSETTS	Ocean Engineering Curricula	Massachusetts Institute of Technology
	Student Foreign Laboratory (Engineering Experiments)	Massachusetts Institute of Technology
	Interdisciplinary Systems Design	Massachusetts Institute of Technology
MICHIGAN	Underwater Technology Laboratory	U. of Michigan
	Recreational Scuba Diving Population/Safety Survey and Public Education	U. of Michigan
MISSISSIPPI/ALABAMA CONSORTIUM	Development of Oceanographic Instrumentation Course	Mississippi State U.
NEW YORK	Coastal Zone Management Training for Local Officials	State U. of New York
	Aquabusiness Management Training Seminars	SUNY/Cornell
	Sea Grant Traineeships	SUNY/Cornell
	Public Service Legislative Studies by Students and Their Professors	SUNY/Cornell
OREGON	Professional Training in Ocean Law	U. of Oregon
	Professional Training in Marine Resource Management	Oregon State U.
	Commercial Fishing Technician Training	Clatsop C.C.
	Marine Technician Training	Clatsop C.C.
RHODE ISLAND	Ph.D. in Economics Marine Resource Economics Option	U. of Rhode Island
	Ocean Engineering–Graduate Program	U. of Rhode Island
	Master of Marine Affairs	U. of Rhode Island
	Fisheries and Marine Technology	U. of Rhode Island
TEXAS	Ocean Engineering Program	Texas A&M U.
	Aquatic Animal Help	Texas A&M U.
	Institutional Seminar Series in Coastal Zone Management	Texas A&M U.
	Teacher Certification in Marine Sciences	Texas A&M U.
	Recreation Management/Development in the Coastal Zone	Texas A&M U.
	Crustal Evolution Module for 8th Grade Instruction	Texas A&M U.
	Oceanic and Marine Technology	Texas A&M U.

SCUBA class at the University of Maryland.

Sea Grant Table XV—3

WASHINGTON	Marine Studies—Marine Resource Economics	U. of Washington
	Law and Marine Affairs	U. of Washington
	New Courses in Fisheries	U. of Washington
	Interdisciplinary Ocean Engineering Systems Design Course	U. of Washington
	Interdisciplinary Curricula Development and Research	U. of Washington
	Alternative Impacts of the Law of the Sea on Organization of Policies in Marine Affairs	U. of Washington
	Program and Marine Technology Affairs	U. of Washington
	Underseas Technician Program	Highline C.C.
	Ecological Baseline Monitoring Study for Central Puget Sound/Marine Technician Training	Shoreline C.C.
	Petroleum Transportation and Handling Program	Seattle Central C.C.
	Marine Mechanics Career Training	Clover Park Education Ctr.
WISCONSIN	Problems in Oceanography	U. of Wisconsin
	Basic Scuba Instruction	U. of Wisconsin
	Maritime Transportation	U. of Wisconsin
	Special Education Program	U. of Wisconsin
	Marine Communications Training Program	U. of Wisconsin
AMERICAN SAMOA	Commercial Fisheries Development	Grays Harbor C.C. (Washington)
GUAM	Marine-Related Manpower Survey	U. of Guam

Marine Advisory Services

The Pell-Rogers Act called for the establishment and operation of a Marine Advisory Service (MAS). Not only would MAS draw on the experience and philosophy of the Agriculture Cooperative Extension Service, but it also would address a broader range of interests and, of course, would concern itself with coastal and marine matters. Still underscoring the principle of local response to local needs, it would be operated by the Sea Grant institutions themselves. Table XVI summarizes the 1976 level of activity under this category.

MAS's basic role is to provide effective two-way communications between the users and producers of knowledge. Though not the only one, MAS should be a main source of information for the Sea Grant Director on the needs and opportunities the institution should address. On the other side of the loop, once the Sea Grant scientists and engineers have done their jobs, the MAS job is to pass the information on to those who need it. Actually, a properly functioning and fully utilized MAS is integral throughout the loop. MAS uncovers and defines the problem. It communicates this to the Sea Grant Director. It works with scientists and engineers or puts them in touch with one or more of the user groups who will work with the Sea Grant team while the team seeks an answer. This helps to keep the effort realistic and on track. Then, once MAS personnel have passed the information, technology, gear, whatever, on to those who need it, they will stick with it through its initial application to help clear any snags that may develop.

The core effort of the Marine Advisory Service is the Marine Extension Agent—Sea Grant's man or woman on the spot. Usually, the agent is a member of the community he or she serves. Depending on the character of that community, the agent works closely with commercial fishermen, fish farmers, sport fishers, charter boat captains, marina operators, boatyard operators, port managers, other marine industry, primary and secondary school teachers, civic groups, municipal and county governments, and State and Federal agencies. He or she is a participant as well as observer. The agent becomes known and trusted and develops a reputation for being on hand when needed, for understanding the problem, for being sympathetic, and for making a real effort to help.

Sea Grant Table XVI

Marine Advisory Services
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget(1) ($-million)	Active Projects		Federal Funds		Matching Funds	
		Number	Average Cost Per Project ($)	($-million)	Per Cent of Total Federal Sea Grant(2)	($-million)	Per Cent of Total Program Budget(3)
Marine Extension Service	5.2	53	98,000	3.3	14.3	1.8	36
Other Advisory Services	3.4	60	56,000	2.2	9.6	1.1	34
Category Totals	8.5	113	76,000	5.6	23.9	3.0	35

(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.

In this capacity, the Marine Extension Agents not only become familiar with problems, but, with the broader perspectives they bring to the job and, with their knowledge of the resources available, they are able to recognize opportunities which others may overlook and to anticipate problems in time to avoid them. Clearly, the Sea Grant Director relies heavily on the MAS in developing the program to be submitted to the NOAA Office of Sea Grant each year for approval.

While Marine Extension Agents play a vital role, they are nevertheless only a part of a much broader mandate to serve the whole Sea Grant constituency. This mandate includes keeping the general public aware of coastal and marine resource issues and alternatives. It includes the establishment and maintenance of liaison with State and local governments. And, it includes the organization and publication of the results of Sea Grant research in such form that they are made available quickly and usefully to anyone with an interest in the topic. In carrying out this mission, the Marine Advisory Service employs a variety of tools, media, and techniques, such as:

- Seminars, workshops, town meetings, and short courses.

- Regional information programs geared more to "use-me" than to "love-me" objectives.

- Continual flow of booklets, pamphlets, and technical bulletins discussing issues, describing new methods and processes, and announcing new regulations or services aimed primarily at the local user but available to anyone.

- Establishment and operation of coastal and marine information centers for local, State, regional, national and general public use.

- Demonstration projects, usually in cooperation with the private sector—floating breakwaters, pair trawling, aquaculture, and others.

- National conferences on domestic and international ocean law, fisheries issues, ocean mining, coastal zone management, 200-mile offshore economic zone, and onshore impact of offshore oil development.

- Museums, exhibits, lectures, and other activities providing high-volume exposure of the general public to marine knowledge and issues.

- Continuing education programs both in the field and in the classroom and addressing a wide range of subject matter.

- Newsletters and other periodic and serial publications.

- Press releases and articles for local and national publications.

- Radio, television, and movie public service announcements and documentaries for public and commercial broadcast media and for community and private showings.

Professional fishermen listen to explanation about taxes from Internal Revenue Service representative.

- Development and guidance of coastal and marine programs for 4-H Clubs, Boy and Girl Scout Troops, civic, and other groups.

- And, provision for prompt responses to inquiries.

This may sound like a recipe for a massive bureaucracy, but it has not worked out that way. The entire MAS, including Marine Extension Agents, totals only about 200 people. This contrasts with some 17,000 County Agents in the Agriculture Cooperation Extension Service.

In addition to those serving within States, two cooperative regional Marine Advisory Services have been established: (1) PASGAP (Pacific Sea Grant Advisory Program) including California, Oregon, Washington, British Columbia, Alaska, Hawaii, and the regional office of the National Marine Fisheries Service; and (2) NEMAS (New England Marine Advisory Service) including Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York. A third regional MAS operation, the Great Lakes Sea Grant regional MAS operation, the Great Lakes Sea Grant Network, is being planned. It will include the States of Michigan, Minnesota, New York, and Wisconsin. Additionally, other regions are contemplating similar associations. These organizations handle projects and publications of regional, rather than strictly local interest and share unique facilities and resources. Though they are in addition to, rather than in place of, local Marine Advisory Services, they are operated in such a manner that they provide superior service at less cost than if the indivdual MAS's tried to do it all themselves.

The nationwide Sea Grant network currently produces about 50 informational products a month —project reports, technical bulletins, atlases, and other printed materials. The cumulative total exceeds 3,000 publications. As they are issued, these are noted and briefly reviewed in *SEA GRANT '70s*—a monthly newsletter providing national Sea Grant coverage and now being published by the Sea Grant program at Virginia Polytechnic Institute and State University. They are also listed in the annual *SEA GRANT PUBLICATIONS INDEX*. Sea Grant publications usually can be obtained from the issuing institution, or they may be examined at or obtained through interlibrary loan from the National Sea Grant Depository, Pell Memorial Library, University of Rhode Island, Narragansett, RI 02882.

In addition, Sea Grant institutions publish a large number of newsletters. Most of these serve local or regional audiences, and some of them are quite restricted in their audience appeal—such as primary and secondary school teachers, local commercial fisheries, and recreational audiences.

As a result of Sea Grant, coastal and marine information centers have been established in Rhode Island, New York, Delaware, Virginia, North Carolina, Florida, Louisiana, Texas, California, Oregon, Washington, Hawaii, Wisconsin, and Michigan. Some of these employ computer archiving, indexing, and cross-referencing and are programmed to interface with various analytical, ecologic, and economic models.

The MAS works directly with people. Its activities are extremely varied. In the northwest, tempers were flaring as towboats carried away surface markers and other gear of dungeness crab fishermen. MAS avoided a serious confrontation by bringing the two opposing groups together for face-to-face talks—resulting in a sharing of their waterspace rather than warring over it. Similarly, North Carolina Sea Grant is working to reduce the friction between commercial and sport fishers along the Outer Banks—again simply by bringing the two groups together to talk over their needs and concerns. Basically, the MAS is a people-to-people effort involving hundreds of thousands of direct contacts with the public each year—more than 50,000 with fishing people alone—and literally millions of contacts through its media efforts.

MAS activities range from a shark workshop in Florida to defuse the ignorance and fear generated by the movie "Jaws," a cobia sportfishing clinic in South Carolina, and a telephone "hot line" for sport fishers to call in Delaware to learn where "they're biting today," to technical assistance to Texas shipyards in controlling waste discharge, a survey of the elver (young eel) resource in Maine, 2-week visits between Oregon and Michigan charter boat operators (funded by two tackle manufacturers) for an exchange of ideas and experiences, series of radio broadcasts in Alaska in the Yupik language, advising Alaskan natives in their own tongue about new developments in fishing and about significant questions affecting their survival and, at Wisconsin, a continuing program of weekly, 2-minute "Earth Watch" radio spots covering ecological and environmental matters and regularly used by over 100 radio stations in the Midwest. Table XVII provides a broader summary of MAS activities.

MARK V DEEP SEA
DIVING OUTFIT
WEIGHT HELMET 54
BELT 84
SHOES 35
DRESS 13

Sea Grant-sponsored diving exhibit at the University of Hawaii captures the attention of a future diver.

Sea Grant Table XVII

Sea Grant-Supported Marine Advisory Services Projects (1967-1976)

ALASKA
- Advisory Field Program
- Public Participation Workshop
- Alaska Seas and Coasts

ARIZONA

CALIFORNIA
- Advisory–*Extension Program*
- Marine Extension Program
- Ocean Education for the Public
- Publications and Advisory Services
- Directory–*Services for Mariners*
- Finance Workshop–*Commercial Fishermen*

CONNECTICUT
- Advisory Services Program

DELAWARE
- Advisory Services Program
- Public Education Program
- Artificial Reef Project
- Coast Guard–*Mariner Liaison*

FLORIDA
- Marine Advisory Program
- Research Conference–*Game Fish*
- Public Conference–*Sharks*

GEORGIA
- Advisory Services–*Fisheries*
  General
- Fishery Cooperative–*Feasibility Study*

HAWAII
- Marine Advisory Program
- Publication Program
- Planning Services–*Research and Education*
- Marine Atlas–*Hawaii*
- Information Center–*Ocean Science*
- Legislative Workshop–*Marine*

LOUISIANA
- Marine Extension Service
- Publications and Information Dissemination
- Advisory Services–*Fisheries Interests*
- Advisory Services–*Legal*
- Food Studies–*Marine*

MAINE/NEW HAMPSHIRE CONSORTIUM
- Fisheries Extension Service
- Public Education
- Advisory Services–*Publications*
- Seafood Industry–*Development*
- Communications and Information Services
- Ocean Engineering
- Coastal Zone Management

MARYLAND
- Advisory Service Report
- Balance of Payments–*Ocean*

MASSACHUSETTS
- Advisory Services–*Development, Operation, and Management*
- Marine Extension Service
- Advisory Service–*Marine Industry*
- Conference–*Marine Careers*
- Sea Grant Lectureship
- Public Education and Training
- Communications/Information Project

MICHIGAN
- Marine Advisory Service
- Communications Program
- Conference–*Shorelands Management*
- Sea Grant Activities–*Visual Display*

MINNESOTA
- Marine Advisory Services

MISSISSIPPI/ALABAMA CONSORTIUM
- Mississippi Advisory Services
- Alabama Advisory Services
- Specialists Support
- Mississippi Sea Grant Newsletter

NEW JERSEY
- Marine Advisory Service

NEW YORK
- Marine Advisory Service–*New York State*
  Eastern Lake Erie

NORTH CAROLINA
- Continuing Education–*Fishermen*
- Advisory Services–*Marine Industry*
  Seafood Science
  Coastal Land Use
  Coastal Recreation
- Electric Shrimp Trawl–*Tests*
- Marine Advisory Newsletter
- Cooperative Marketing Information

OHIO

OKLAHOMA

OREGON
- Advisory Field Program
- Advisory Education–*Oceanography and Engineering*
  - *Seafood Technology*
  - *Marine Economics*
- Public Education
- Communications–*Marine Advisory*
- Diseases–*Fish and Shellfish*
- Seafood Science–*Information Transfer*
- Marine Data Display
- Ocean Law
- Business Management–*Fishermen*

PENNSYLVANIA

RHODE ISLAND
- Marine Advisory Service
- National Sea Grant Depository
- Demonstration–*Midwater Trawl*
- Small Marinas–*Ecological Study*
- Workshops–*For Public School Teachers*
- Workshop–*Maritime Transit*

SOUTH CAROLINA
- Marine Advisory Service

TEXAS
- Institutional Advisory Services
- Advisory Services–*Business Management*
- Fisheries and General Extension
- Marine Education Program
- Marine Resources Information
- Sea Grant '70s *(Now Published at Virginia Polytechnic Institute and State University)*
- Coastal Resources Management

VIRGINIA
- Advisory Program–*Food Science and Technology*
- Extension Agents and Publications
- Business Management–*Seafood Industry*
  - *Sea Grant Professionals*
  - *Lending Institutions*
- Engineering Advisory Program
- Public Education
- Aquaculture Information

WASHINGTON
- Advisory Services–*Coastal*
  - *North Sound*
- Field Activities Support
- Seafood Technology Support
- Puget Sound Fishermen Support
- Sea Search
- Communications Program
- Industry-Student Problem Solving
- Workshop–*Artificial Bait*

WISCONSIN
- Food Science and Fish Program
- Lake Recreation Development
- Advisory Services–*Aquaculture*
- Great Lakes Heritage
- Bicentennial Guide–*Great Lakes*
- Shore Erosion–*Radio Program*
  - *Newspaper Column*
- Radio Programming–*Ocean Soundings*
- Sea Grant Communications
- Data File

DISTRICT OF COLUMBIA

AMERICAN SAMOA

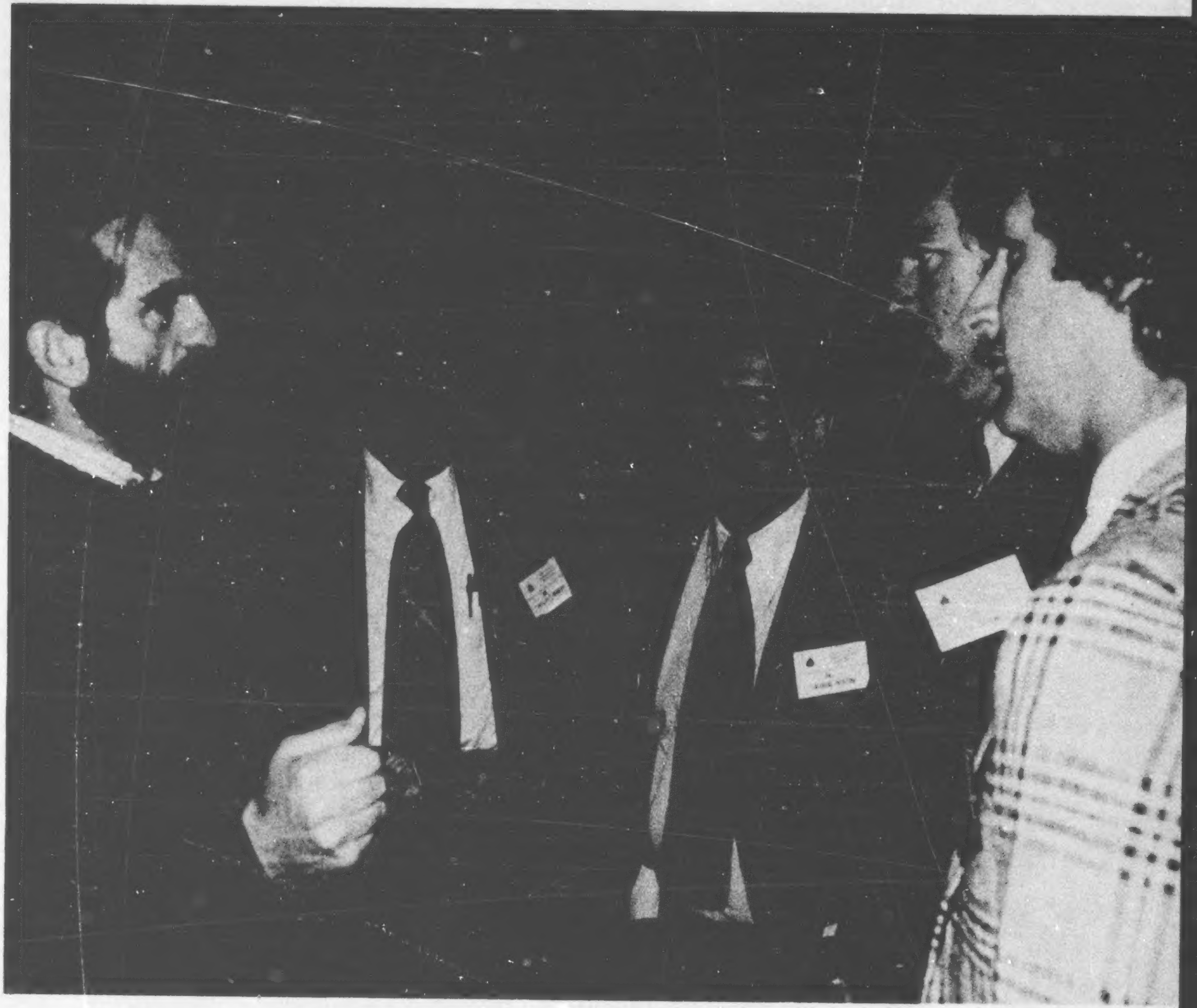
GUAM
- Marine Advisory Program
- Marine Products Marketing–*Feasibility*
- Guam-Microneseian Marine Bibliography

TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO

NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.



Program Management and Development

Program Management and Development is concerned with Sea Grant program management, exploring and implementing new management techniques, expanding participation in Sea Grant efforts, preliminary exploration of proposed major new projects, and meeting unforeseen contingencies. Table XVIII shows the level of activity under this category.

The NOAA Office of Sea Grant does not have a set formula for the local Sea Grant management organization, and thus these vary among the several Sea Grant institutions. The management goal, however, is consistent: to develop and operate a structure which functions well within the institution and which produces a program which is responsive to the needs and opportunities of the community it serves.

Ancillary goals include: a broad participation, not only by as many academic campuses and departments as possible, but also by industry and State and Federal agencies; attraction of top talent to the program; marketing the Sea Grant-developed capability to industries and agencies outside of the Sea Grant program; expanding both the volume and sources of matching funds; and, on the basis of proven performance, establishing Sea Grant as a vital and relevant element of the

Sea Grant Table XVIII

Program Management and Development
(Fiscal Year 1976 Awards)

Project Subcategory	Total Program Budget(1) ($-million)	Active Projects		Federal Funds		Matching Funds	
		Number	Average Cost Per Project ($)	($-million)	Per Cent of Total Federal Sea Grant(2)	($-million)	Per Cent of Total Program Budget(3)
Program Administration	4.1	30	138,000	2.3	10.1	1.8	43
Program Development	0.7	14	53,000	0.6	2.4	0.2	24
Category Total	4.9	44	111,000	2.9	12.5	2.0	40

(1) This includes NOAA Sea Grant funds plus local matching funds.
(2) This is a percentage of the total NOAA Sea Grant budget for all seven major categories of activity.
(3) This is the matching fund percentage of the total program budget in the far left column.

coastal and marine resource development and management effort.

Keeping in mind that no two Sea Grant management structures are exactly alike, a typical and effective system might work as follows. There is a Sea Grant Director who is in charge of, and responsible for, the whole program. The Directors report directly to the institution's (or State university system's) top management. There is an internal advisory body with the Director serving as chairperson and the membership consisting, variously, of institutional department heads, Sea Grant principal investigators, coordinators at various campuses, and other administrators of the institution.

For external advice and counsel, heavy reliance is placed on the MAS with its broad and continuing contact with the user public. There frequently is also a Sea Grant Advisory Council, sometimes chaired by the Director and sometimes with an elected chairman. The membership consists of representatives of user groups and community leaders outside of the Sea Grant institution. New York, for example, has two such advisory councils—one for the Great Lakes which includes two Canadian members, and one for the Atlantic marine district.

There also may be a series of panels or committees—at Rhode Island called WAGs (Work Area Groups)—to provide review and advice on specific projects and proposals in the area of their specialty (e.g., fisheries, recreation, ports and harbors, wetlands). Membership in such groups may be from the institution's Sea Grant investigators, marine extension agents, outside groups being served, State and Federal agencies. They help to keep research pragmatic, technologically sound, responsive, and on track.

As noted, no two Sea Grant management structures are the same; thus, there are many variations. All, however, feature both internal and external input, peer review, and constant interaction with the user groups.

Program Development serves two basic functions. It enables Directors to carry out or authorize exploratory work (a) to see if a project is worth pursuing without initially having to make a major commitment, and (b) to develop sound project design in order to produce proposals which are both relevant and efficient. The philosophy here is to spend a little money first in order to save more money and avoid possible project failure later.

The second principal function of Program Development is to provide for contingencies. This enables Directors to respond to crisis needs, the resolution of which cannot await the completion of the annual cycle of proposal writing, review, and approval. It also permits directors to take advantage of special opportunities which might not be around six months or a year later. Such opportunities include: the chance to participate jointly—therefore, less expensively—in a particularly desirable project, or the occurrence of unusual or unique situations (environmental, perhaps) which are transient but nevertheless of significance to Sea Grant interests.

Table XIX summarizes the nature of the projects supported under Program Management and Development.

Sea Grant Table XIX
Sea Grant-Supported Program Administration and Development Projects (1967-1976)

- ALASKA
  - Program Administration
  - University-Petroleum Industry Cooperation
- ARIZONA
- CALIFORNIA
  - Program Planning and Development
  - Program Administration
  - Administration and Management
  - Rapid Response Capability
  - Fish Industry Advisory Committee
- CONNECTICUT
- DELAWARE
  - Program Management
- FLORIDA
  - Program Administration
  - Management-Administrative Functions
  - Contingency Funds
  - Program Development
- GEORGIA
  - Management and Development
- HAWAII
  - Program Management
  - Sea Grant College–*Management Framework*
  - Publications Office–*Development*
- LOUISIANA
  - Program Administration
  - Field Logistic Support
  - Environmental Studies–*Matching Funds*
- MAINE/NEW HAMPSHIRE CONSORTIUM
  - Administration and Development
  - New Hampshire Component–*Management*
  - Sea Grant Library/Computer Index
  - Advisory Service Development–*New Hampshire*
- MARYLAND
- MASSACHUSETTS
  - Program Management and Development
  - International Technology–*Sharing Alternatives*
  - Project Development Opportunities
  - Ocean Utilization Professorships–*Establishment*
- MICHIGAN
  - Program Administration
- MINNESOTA
- MISSISSIPPI/ALABAMA CONSORTIUM
  - Program Management and Development
- NEW JERSEY
  - Program Planning and Management
- NEW YORK
  - Program Management
  - Communications and Publications
  - Sea Grant Institute–*New Initiative*
  - Sea Grant Consortium Coordination
  - Local Input Development
  - Food Science Seminar–*Taping, Dissemination*
- NORTH CAROLINA
  - Management and Development
- OHIO
- OKLAHOMA
- OREGON
  - Administration and Development

PENNSYLVANIA

RHODE ISLAND
  Management and Development

SOUTH CAROLINA
  Administrative Project

TEXAS
  Sea Grant College–*Industrial Activities*
  Program Direction and Administration

VIRGINIA
  Administration, Planning, Coordination

WASHINGTON
  Program Management
  Contingency Funds

WISCONSIN
  Program Administration and Development

DISTRICT OF COLUMBIA

AMERICAN SAMOA

GUAM
  Program Management

TRUST TERRITORIES

VIRGIN ISLANDS

PUERTO RICO

NOTE: This is not a complete list of all project areas undertaken during Sea Grant's first 10 years. Rather, it is intended simply to be representative of the nature and variety of activities under this category.

"To my mind there are two extremely important areas for Sea Grant in the future: First, working with industry, government, and the people at large in making extended fisheries jurisdiction work. If there is something the ideal Sea Grant institution knows how to do, it is how to make things work. It has the local routes. It has access to the academic community, to local and State government, and to the Federal government and several of the operating agencies without being a direct part of those agencies; thus, the stigma of big brother looking over your shoulder does not attach to Sea Grant if it works right.

"Secondly, Sea Grant institutions can serve in a similar role in making coastal zone management work and making it phase in smoothly with broader based land use as it must in the future. Here are two resources: One, the traditional common property resource of fisheries which we want to manage in what are traditionally international waters with all the 'freedoms' this implies. The second resource, our coastal environment—at the interface of land and sea and of private and public property rights—is also an extremely difficult area to manage. This is a tremendous undertaking, and if it is going to be done without excessive fractures in State-local relations and in State-Federal relations, it is going to take some very careful and dedicated work in the localities and the regions."

Niels Rorholm, Coordinator
Sea Grant College Program
University of Rhode Island

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Sea Grant Benefits

part 3

When a $2,400 demonstration of pelagic pair trawling enables half a dozen U.S. fishermen to increase their monthly receipts by $40,000, and the technique is quickly adopted by others . . .

When a $2,820 proof that "pink oysters" are safe and nutritious results in the sale of $500,000 worth of oysters which otherwise would have been rejected . . .

When a $116,000 underwater survey finds and describes economically recoverable sand deposits worth more than $100 million . . .

When a 4-year Sea Grant investment of $150,000 attracts $300,000 of State and industry funding, and when the combined efforts produce increases in retail sales of precious coral from $2.6 million in 1971 to $11.4 million in 1975 and hike employment from 200 to 500 . . .

. . . with track records like these, it is not difficult to show that these were worthwhile efforts with beneficial and specific cost/benefit ratios. The Sea Grant tally of quantifiable benefits such as these is growing. Frequently, the Sea Grant project results in an expansion of the tax base which produces tax revenues in one year which are greater than the public investment cost of the project responsible. And, while that cost is in effect, a one-time thing, the added tax revenues continue, and usually expand, year after year. Under such circumstances it is easy to say: "That's good stuff; let's do more of it."

It is not so easy, however, to place a specific dollar benefit tag on Sea Grant's contribution to the creation of a broad base of aquaculture technology, on the education of interdisciplinary specialists in coastal zone management, marine affairs, and ocean laws, or on the development of sounder data bases and predictive analytical techniques for better decision-making in government.

It is even more difficult, in fact quite impossible, to compute specific dollar benefits from the introduction of institutions of higher learning to new and exciting concepts of adaptive education and to new and challenging roles of community service; or from the establishment of a direct communications link between the producers and users of knowledge; or from the gradual evolution of a universally better informed and more aware, involved public.

While some Sea Grant activities produce measurable benefits—usually where specific technologies are applied to specific tasks (See Table XX)—the majority does not. In the final analysis, the Sea Grant goal is to help to produce a society which is more competent, more confident, and more optimistic—or, to resurrect an old cliche, healthier, wealthier and wiser.

This means crises and conflicts which might have arisen but did not; opportunities which might have been missed but were not; irreplaceable resources which might have been destroyed but were not; new efficiency and foresight in government and greater confidence in its decisions which might have been lacking but were not—all because of the Sea Grant process. The worth of benefits such as these is no more computable than are the differences between American agriculture because of Land Grant and what it might have been without it.

Many benefits, though unmeasurable, are identifiable. They are numerous and varied—frequently of an unanticipated, secondary, or fallout nature. Derived mostly from the Sea Grant Directors' own perspectives, Table XXIV summarizes some of these immeasurables. None of them is entirely abstract. They produce tangible benefits for the institutions, the faculty, the students, the local communities, and the Nation.

The payoff is mostly in futures, and so it probably always will be—for whatever Sea Grant's current level of accomplishment, it will always have new and challenging horizons in view. This does not mean an ever-expansive, runaway budget. Rather, it is the straightforward process of undertaking new tasks as old ones are completed. All of them have as goals: people who are better off economically; government which is less divisive, less abrasive, and more responsive; resources that are used, taken, and managed more wisely, and a quality of life that constantly improves.

In brief, the ultimate benefit from the Sea Grant process is a better America.

Sea Grant Table XX
Examples of Specific Benefits

GEORGIA

Challenge	Cut 10 percent product loss from sawing frozen fish blocks into smaller pieces for breading—some 400 pounds a day in a small plant.
Solution	Collect, reconstitute and bread fish sawdust.
Benefit	Once-wasted product sells for 50¢ a pound.
Investment*	$93,900.

GEORGIA

Challenge	Improve economic efficiency of Georgia shrimp fishermen.
Solution	Debug and adapt Gulf of Mexico twin trawl (two small, side-by-side nets replace one larger one) with fishermen's cooperation, demonstrate method.
Benefit	Increase trawling efficiency by 60 percent. Technique is adopted by others.
Investment*	$290,500.

HAWAII

Challenge	Expand domestic sources of precious coral. Increase harvest efficiency. Develop sound resource management program.
Solution	Use modern Scuba gear and submersibles (STAR-II) to discover and survey resources. Employ same gear for selective harvesting to 1,200-foot depth.
Benefit	Import dependence reduced from virtually 100 percent to less than 25 percent. Retail sales increased from $2.6 million to $11.4 million a year. Employment up from 100 to 500 people. Federal and State tax revenues up by $500,000 a year.
Investment*	$148,522 over a 4-year period; matched by $294,277 State and industry funds.

HAWAII

Challenge	Find offshore sand deposits for restoring and maintaining beaches.
Solution	Conduct survey and assessment.
Benefit	Location of six recoverable deposits of 20 to 70 million cubic yards each.
Investment*	$290,500.

LOUISIANA

Challenge	Find way to reverse U.S. Food and Drug Administration (FDA) ban on interstate shipment of baby green turtles because of danger of salmonella infection.
Solution	Dip eggs in terramycine before incubation.
Benefit	Will restore $2.5-million market for 150 growers—if FDA can be convinced of the safety of the process.
Investment*	$30,600.

MASSACHUSETTS

Challenge	Reduce bacterial and viral load in sewage discharged into coastal waters.
Solution	Develop and test high-energy electron irradiation purification technique.
Benefit	Sea Grant-supported work led to a $113,000 National Science Foundation grant and a subsequent grant of $198,000 to build full-scale pilot plant in cooperation with the Metropolitan District Commission.
Investment*	$19,300.

NEW YORK

Challenge	Find new sources of construction aggregate for concrete.
Solution	Survey the underwater resources of Lake Ontario.
Benefit	Found several sand deposits, including one worth $90 to $150 million.
Investment*	$115,766.

NEW YORK

Challenge	Find way to recover and market some of the 8,000,000 pounds a year of fish filleting wastes produced in New York City alone.
Solution	Use poultry deboning machines to recover 60 percent in form of white meat left on racks (what's left after fillets are removed); reconstitute and bread it.
Benefit	Marketable at 50¢ a pound compared to 3¢ a pound as mink food.
Investment*	$26,200.

NEW YORK

Challenge	Enable marinas forced to close when rising Lake Erie water level covered breakwaters to reopen.
Solution	Install a 900-foot floating breakwater using Rhode Island Sea Grant developed "old-tire" design.
Benefit	Marine revenues of $75,000 a year restored.
Investment*	$5,000.

NORTH CAROLINA

Challenge	Improve fishermen's ice-holding and fish-keeping capabilities.
Solution	Sprayed-in-place polyurethane insulation of fish holds.
Benefit	$100,000 saving in first year for six vessels and two ice-holding facilities.
Investment*	$6,500.

NORTH CAROLINA

Challenge	Increase earning opportunities for commercial fishermen.
Solution	Help develop local fishery and export market for eels.
Benefit	In first year 29 fishermen earned $75,000 harvesting eels.
Investment*	$10,000.

OREGON

Challenge	Improve fishing efficiency
Solution	Modify Atlantic Western trawl to increase catching efficiency.
Benefit	Catch efficiency up 30 to 100 percent; local catch up by over $2.5 million a year.
Investment*	$14,000.

OREGON

Challenge	Improve landed quality of fish.
Solution	Develop superior fish hold liners; also less expensive than old method.
Benefit	Higher quality landed product and $290,000 direct cost saving for 129 vessels.
Investment*	$5,000.

OREGON

Challenge	Restore chum salmon fishery depleted by urbanization and other changes.
Solution	Raise salmon in hatcheries; release them to sea; and harvest them when they return as adults—called ranch farming.
Benefit	Investment by private industry. Four private hatcheries in operation; 15 additional license applications in. Anticipate 2 to 3 million-pound harvest in 1980 with \$3 to \$5 million to farmers, with additional take by offshore commercial and sport fishers of 3.5-5.5 million pounds, and State and Federal tax revenues increased by more than \$1 million a year.
Investment*	\$93,500.

RHODE ISLAND

Challenge	Improve fishing efficiency.
Solution	Bring Irish fisherman over to explain European pelagic pair trawling.
Benefit	Increased local catch by 6,000,000 pounds in first three months of its adoption and trial. Practice now spreading up and down Atlantic coast.
Investment*	\$2,400.

RHODE ISLAND

Challenge	Develop an effective breakwater that is inexpensive and easily installed and removed.
Solution	Design, produce and proof-test floating breakwater made of old car tires.
Benefit	A breakwater that can be built and put in place for less than \$6 a foot, and which is enjoying wider and wider use—e.g., Rhode Island, New York, and Washington. Also helps with the tire disposal problem.
Investment*	\$54,000.

VIRGINIA

Challenge	Outbreak of "pink oysters" and customer refusal to accept shipments.
Solution	Demonstrate safety, nutrition, and that cooking eliminates color.
Benefit	\$500,000 shipment accepted.
Investment*	\$2,820.

VIRGINIA

Challenge	Improve methods and reduce cost of pasteurizing crabmeat.
Solution	Develop flexible film containers to replace cans.
Benefit	First firm to adopt process saved \$51,000 on 300,000 pounds in first year.
Investment*	\$3,350.

WASHINGTON

Challenge	Demonstrate commercial feasibility of NMFS (National Marine Fisheries Service, a NOAA agency)-developed technology for pen-rearing of pan-size salmon.
Solution	Join with Domsea Farms, Inc., to conduct full-scale experiments.
Benefit	Production of pen-reared salmon brought from nothing in 1970 to some 1,700,000 pounds in 1975 at a market price of \$1.50 a pound; attracted private investment and increased tax revenue potentials by more than \$700,000 a year.
Investment*	\$100,000.

* Investment represents the total of NOAA Sea Grant funds committed to the project. It does not include matching funds or private investment.

Examples of Immeasurable Benefits

Primary Beneficiary

How Sea Grant Benefits the University

- Augments roles, missions, and stature of the university in the community it serves.
- Encourages mission-oriented, interdisciplinary programs of higher education which are responsive and adaptable to the changing needs of society.
- Fosters the evolution of dynamic, interdisciplinary team approaches to the fulfillment of a broad range of community needs and aspirations.
- Capabilities thus produced attract demands for services and grant and contract funds from sources other than Sea Grant—i.e., Federal and State agencies, industry.
- Opportunity for college-based researchers to work on marine-oriented problems with a practical short-term payoff convinces many, who at first opposed Sea Grant, that good research can be done within the boundary conditions of applied goals.
- Starts university faculty and administrators alike thinking in terms of overall marine objectives and of the value of being *the* State marine university.
- This marine commitment attracts capable faculty and motivated students.
- Interdepartmental and interinstitutional cooperation favors development of complementary, rather than competitive, courses, services, and capabilities.
- Continuous feedback loop between faculty and Marine Advisory Service personnel keeps the faculty and the university administration in touch with the changing needs of society.
- Sea Grant fosters interinstitutional transfer of information and services.
- Provides the university with research opportunities which, without Sea Grant, would not have been possible.

- Matching fund requirement fosters beneficial citizen and State involvement in the university function, and vice-versa.

- Gives the university, the public, and the State new perspectives on the marine environment which otherwise would not have been possible.

- Permits presentation of marine accomplishments as selling points for the university before the State legislature.

How Sea Grant Helps the Student

- Presents the students with an exciting diversity of courses and degree programs which previously did not exist.

- Encourages competence among the students and enables them to realize diversity in their academic experience which greatly enhances their subsequent value to society, including prospective employers.

- Gives students the opportunity to participate in projects and to travel to places which otherwise would not have been possible.

- Gives students early exposure to the practical aspects of their academic learning through problem-oriented research, work-study, and internships with both government and industry.

- Helps interest students, faculty, and community in applied marine work.

- Provides the financial incentive to university administrations to try totally new courses, degree programs, and other innovations in contemporary education.

- Allows and encourages the university educational process to grow, adjust, and adapt to changing technologic, economic, and societal needs—thus assuring continued educational relevance and more and better job opportunities for the institution's graduates.

Sea Grant's Role in the Community

- Enables the comprehensive and diversified resources of universities to be marshalled into a variable-response capability to serve vital community needs and opportunities.

- Opens effective avenues of communications between the university and both the community it serves and agencies concerned with the marine environment.

- Catalyzes beneficial, cooperative, and working contact among the institution, State and Federal agencies, industry, and other groups.

- Provides specialized assistance in advance planning for the management of coastal and marine resources and for the implementation of those plans.

- Provides the governor, legislature, agencies, and others with a quick-response, specialized source of expertise for dealing with critical or unusual problems.

- Offers an independent, objective source of advice and counsel which is outside of both the State and Federal government systems.

- Primes the pump for a greater concentration of State funds in the area of coastal and marine research and education.

- Contributes, through its knowledge of and close association with the marine community, to greater efficiency in the execution of other Federal programs.

- Demonstrates how Federal-local partnerships can be made to function effectively.

- Shows how a minimum Federal input can produce maximum local benefits.

- By virtue of its chain store characteristic, provides one-stop shopping center for displaying a broad inventory of talents and capabilities.

- Matches local involvement to local responsibility —a major benefit of the matching fund requirement.

- Predicates activities on the genuine needs of the States.

- Fulfills critical and emerging needs for special professional and technical skills through adaptive curriculum development.

- Promotes manpower sharing for greater productivity and lower costs.

- Contributes to sound economic growth and expansion of the tax base.

- Provides its benefits at a minimum net added cost to the taxpayer because it largely utilizes existing personnel and facilities.

Sea Grant Benefits Extend to Business and Industry

- Upgrades efficiency in existing marine industries through positive contributions in technology, methods, resource management, marketing, and bookkeeping.
- Expedites technology transfer within marine industries, from one industry to another, from one part of the country to another, and from abroad.
- Identifies, evaluates, and, if appropriate, determines maximum sustainable yield of previously unknown or underutilized resources and provides basic guidance for their exploitation and marketing.
- Generates and stimulates new marine industries as new resources are discovered and as new technologies and markets are developed.
- Discourages new marine industries where, even though the potentials exist, the technologies and basic marketing infrastructure do not.
- Encourages the development of new domestic and export markets for marine products and services.
- Fosters the creation of new marine job opportunities.
- Helps to assure an adequate and timely supply of trained professionals and technicians.
- Assists in power plant and other industrial siting so as to minimize adverse environmental, economic, and other impacts.
- Contributes to improve management of wastes from marine industries, including conversion of wastes into secondary sources of income.
- Serves as a reactive communications link between the marine constituency and those State and Federal agencies and others which regulate or otherwise may impact upon it.

Sea Grant Meets National Needs

Sea Grant responds to national needs both broadly and specifically. To the extent that it helps localities and regions of the country to greater economic wealth, sound economic growth, better natural resources management, better government, and more relevant educational opportunities, it provides a broad contribution to the national well-being. To the extent that it supports studies of specific naional issues—such as extended fishery jurisdiction, offshore mineral development, deepwater ports, ocean dumping, Law of the Sea, and other significant topics—it directly tackles national problems. This is also true to the extent that Sea Grant-developed capabilities are called on to satisfy the issue-oriented needs of a number of other Federal agencies.

A survey by the Office of Sea Grant shows that for every four projects concerned mainly with local matters, there are two that concentrate on national problems and three which fall in between. Another analysis shows the allocation of Federal Sea Grant funds thus: aquaculture, 23 percent; coastal zone management, 24 percent; fisheries, 12 percent; engineering, 21 percent; and socioeconomic and legal research, 12 percent. Yet another shows research of all types at 61.5 percent, education at 6.2 percent and advisory services at 20.8 percent. No doubt all of these are statisticians' delights, but not only are they of little more than transient interest, they miss the basic point.

The basic point is: so long as the Nation is the sum of its localities—which it is—*everything Sea Grant does contributes to the national well-being.* Look at what it does:

- It fosters greater economic efficiency. This yields greater productivity (output *per unit effort*). This fights inflation.

- It provides for greater utilization of domestic resources. This increases supplies, reduces import dependence, and increases exports. This contributes to a favorable balance of payments in international trade. This also makes the dollar worth more abroad, making imports cost us less and . . . fighting inflation at home.

- It contributes to the expansion of existing, and the introduction of new industries. This creates jobs and investment opportunities, which fights unemployment and fosters economic growth. This expands the tax base, yielding greater tax revenues at no increase in tax rates.

- It produces greater knowledge of resources, the environment, economics, and activities—and how they interplay. This permits sounder, more efficient management by both government and industry. Errors of judgment are fewer, and the costs therefore, are diminished. This leads to better government without a proportional rise in the cost of government. This contributes to a balanced budget. Sounder business management contributes to economic efficiency and growth—more jobs, higher personal and corporate incomes, a broadened tax base, greater tax revenues (and/or lower tax rates), a sounder, more attractive and healthier environment.

Once begun and allowed to proceed, the cycle is self-perpetuating. The only requirement is the continued input of knowledge as new problems, needs, and opportunities arise. It is a cycle of improvement rather than of degeneration. By many different means, in many different areas of activity and in many different parts of the country, this is what Sea Grant does. It helps to reverse the downward trend and to get the upward cycle moving. Then, it continues to support that national "upward mobility" in the economy, the environment, the population, the locality, the region, and the Nation. And, it is based on the most proven and fundamenal principles of the American competitive free enterprise system.

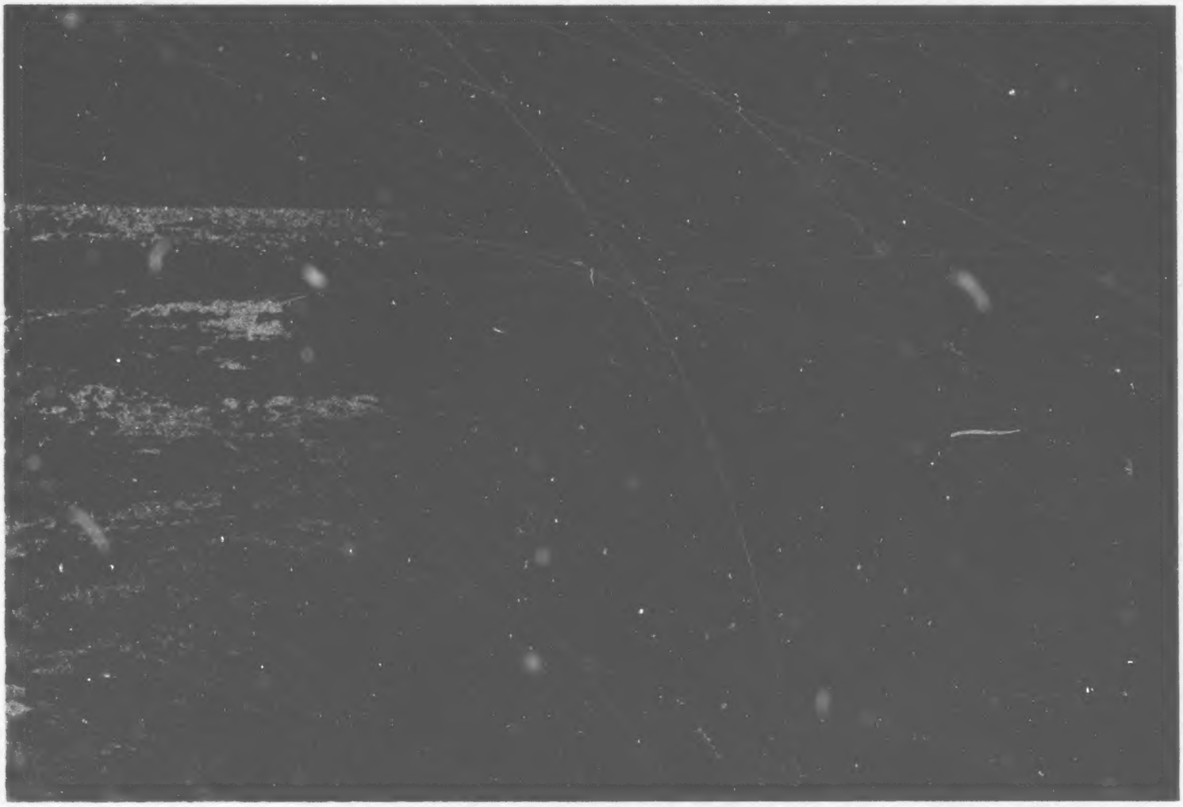
In the final analysis, Sea Grant's greatest contribution to the Nation simply may be that it proved *itself.* Except perhaps that the need was greatest there, that it began in America's coastal States is irrelevant. As a means of achieving wiser use of resources and more confidence and discipline in critical decision-making, it is a process that is responsive wherever the convergence of man and nature creates vital problems of demand, allocation, use, conservation, and equity. Sea Grant philosophies, tools, and methods are as applicable inland as they are alongshore. The university systems are there, and so, more or less, are the problems, the needs, and the opportunities. This inherent universality of the Sea Grant idea, of itself, may hold the greatest potential for national benefit.

Sea Grant Future

Sea Grant's future can be described briefly as "more of the same and better"—concerned with growth and fine-honing of its public service role. By growth is meant neither galloping bureaucracies nor runaway budgets. Leaness should always be a characteristic of Sea Grant in terms of both people and money. Rather, by growth is meant development to its full-service potential in those States where it already exists, its initiation in those coastal States where it does not exist and, throughout the network, constant improvement of the organizations and methods by which Sea Grant institutions perceive and pursue their missions.

By growth also is meant the natural extension of Sea Grant responsibilities commensurate with the growth of its capabilities. This already takes the form of a greater cooperativeness and cohesiveness among the Sea Grant institutions, automatically moving them toward a capability to respond effectively as a unit to national and even international needs. More specifically, in its second decade the Sea Grant network will begin to serve the Federal government in a way that is directly analogous to the manner in which the individual institutions now serve their respective States. One can see the start of this process in the mounting use of "pass-through" funds by other Federal agencies to have Sea Grant support projects of special importance to their missions. It is also apparent in the increasing extent to which other agencies and industry make use of Sea Grant-developed capabilities on a direct grant or contract basis—without going through OSG at all. Greater cooperation and coordination and better communications among the Sea Grant institutions, the encouragement of more multistate Sea Grant projects, the evolution of a 5-year planning capability at the institutional level, and the more direct involvement of representatives from the Sea Grant network in Federal marine policy and planning activities—all current OSG program goals—will strengthen Sea Grant's national response capabilities.

In a small way and in direct support of its domestic missions, Sea Grant is already operating internationally—the transfer of European fisheries technology to U.S. commercial fishermen, the transfer of U.S.-developed plant mariculture know-



how to the western Pacific Rim countries, the broad international involvement of the Law of the Sea Institute, PASGAP and the New England Fishermen's Forum which regularly brings together U.S. and foreign (mainly Russian) fishermen operating in the northwest Atlantic area. Sea Grant's international involvement will almost certainly grow with emphasis on the two-way transfer of knowledge and technology between the United States and other nations. The most important of these transfers may well be the introduction of the Sea Grant process itself to other countries. Informally, at least, this last has already begun—among some of the Pacific Rim countries and in the Soviet Union.

As for specific tasks, many of the key issues of today will demand Sea Grant attention for some years to come. New issues are already emerging, and others are in the wings. Some can be anticipated; some cannot. However, among the tasks Sea Grant is tackling and will be tackling in the future are:

- Survey, assay, and bases for allocation of continental shelf resources.
- Energy from the sea, including not only the offshore siting of thermal electric power plants, but also the direct extraction of energy from ocean currents, vertical thermal gradients, winds, tides, and perhaps others.
- Technology and environmental aspects of offshore mining of minerals and construction aggregates.
- Optimum development and management of fisheries.
- Establishment of aquaculture as an acceptable, compatible, and profitable activity offshore, alongshore, and in America's heartland.
- Determination of coastal and ocean engineering criteria suitable for establishment of standards, insurance risk tables, permitting, and other regulatory activities.
- Techniques for restoration of natural environments both alongshore and offshore.
- Design and testing of novel human-made "natural environments" (*i.e.*, once established they function in a natural manner with little or no human intervention; artificial reefs are a simplistic example) to achieve special local objectives.
- Resolution of the rising number, variety, and intensity of conflicts between *public* and *private* rights in the coastal and marine environments.
- New and acceptable strategies for solid waste disposal.
- Key participant roles in the design, demonstration, and evaluation of major and innovative ways to expand the productive capacity of our coastal and marine resources without further destroying the natural environment—*e.g.*, multiple use offshore platforms and artificial islands for waste disposal and recycling, industrial siting, energy production, deep-draft and other berthing, aquaculture, integrated commercial fisheries complexes, high-intensity marine recreation, and other activities for which a *natural* environment is not a prerequisite.
- Floating cities and underwater factories.
- Novel and innovative approaches to marine recreation.
- Improved energy economics for the whole spectrum of marine activities.
- Man in the sea, including both underwater recreation and underwater work.
- And, in general, smoothing the accelerating extension seaward of many traditionally land-based activities, as well as new and previously untried ventures inspired by civilization's increasing familiarity with the marine environment and its growing dependence on those resources.

Different Needs In Different States

There is no standard size, structure, or spending level to which all States are expected to aspire. There are too many variants. Each State is different, and so are the needs and opportunities which each Sea Grant institution addresses. Size and activities are established by local requirements. Success is measured by the extent to which these requirements are met.

When the local Sea Grant program is turning out professionals and technicians to meet changing constituent needs, when it is providing the knowledge and tools to solve problems and take advantage of opportunities, when it operates an effective alert system for crisis avoidance and resolution, when it provides useful input to its State's coastal and marine resources planning and management efforts, when it works in cooperation with industry, individuals, and local, State and Federal agencies, when it operates an effective program of public education and communications, and when it has become an accepted, valued, and integral part of the total community it serves, this is readily apparent and marks the maturing of Sea Grant. The size and complexity of a particular Sea Grant program is quite secondary. What is of primary importance is that it be appropriate to the need.

In some States, Sea Grant already approaches this level of service. In others, it does not. To achieve this level of service in all States which need and want it is one of Sea Grant's most important second-decade tasks. Responsibility for this effort rests primarily, though not entirely, wtih each State. Congress must appropriate the necessary Federal funds, and OSG must continue to guide and advise. If the States themselves do not seize the initiative, however, no one is going to drag them into the fold.

Future Tasks

Much of what Sea Grant is doing now it will be doing for some years to come—responding to the needs of its constituent communities. There will always be changes of emphasis, of course; as programs progress, one set of needs is met and others emerge. Aquaculture, for example, undoubtedly will progress to the commercial feasibility demonstration phase. Perfection and adaptation of existing environmental models, rather than the development of new ones will be stressed. Recreation will get more attention, as will social, cultural, and economic aspects of coastal and marine resources management. Throughout the entire spectrum of tasks, there will be a special concern with new and innovative ways to take and use coastal and marine resources—ways which are not only economically efficient but which provide more benefits with fewer adverse impacts and fewer conflicts.

Basically, however, Sea Grant will continue to do just what it is doing now. It will continue to develop the information and tools to reduce the element of doubt in critical management decisions. It will seek valuation schemes for rating those aspects (*e.g.*, aesthetic) of coastal and marine resources not customarily priced by market processes. It will continue to expand the number and diversity of user groups with which it has beneficial contact. In education it will work to keep courses up to date and relevant and to encourage the introduction of innovative programs in marine affairs, the humanities, the arts, science and engineering, including new emphasis on exchange programs—work-study, internships—with industry, government and other Sea Grant institutions and involving both students and faculty. It will continue and expand the process of producing an informed electorate. It will keep building economic efficiency with technology research and development and new market exploration. And, it will continue to work strongly and directly in support of the States' coastal zone management efforts. The Sea Grant process already has proved to be effective, low in cost, and highly beneficial. It is not in need of changing, only of fine honing.

In short, the overall role of Sea Grant in the future, as now, is to maintain and develop the processes whereby needs and opportunities are recognized and the talents, technologies, institutions, and laws necessary thereto are provided. By definition, this is a continuous process in which a goal realized is not an end-attainment, but merely the clearing of an obstacle, beyond which new opportunities beckon to contribute to higher returns on both individual and community investments of time, thought, energy, and wealth. If Sea Grant had a motto, it might well be: to realize the greatest gain from, with the least harm to, marine and coastal resources.

Conclusion

Sea Grant is a process for realizing more efficient utilization of human, economic, and natural resources. It is a process for applying wisdom and foresight to management. It is a process through which institutions of higher learning can adapt and respond to changing needs at both the educational and public service levels of their community responsibilities. Sea Grant in action enables people to realize more from their efforts. It helps to achieve an acceptable balance in the use and conservation—both short- and long-term—of natural resources.

Sea Grant embodies the concepts of dynamic, interactive investigation, and response, of adaptive programs of education, of flexibility and functionalism in university approaches to their operations without in any way sacrificing the intellectual and disciplinary integrity of academic standards. Sea Grant marks the difference between the institution which serves traditional approaches to education only and the institution which also systematically seeks better ways to serve the whole of its constituent community.

This intermingling of Sea Grant educational efforts with Sea Grant community service roles and missions is a mutual relationship which benefits both. And, of course, the more the institution successfully addresses and helps to solve community problems and the more it contributes to sound growth and better management, the more meaningful the institution becomes to its State.

While Sea Grant is concerned with the coastal and marine regions of the Nation, the Sea Grant process and the benefits it produces are applicable anywhere the meeting of people, technology, and nature creates problems of allocation, exploitation, conservation, and management. In essence, Sea Grant is simply a process for the full and relevant utilization of the intellectual and other resources of a large university system in a broad and adaptable program of public service. It works as well inland as it does by the sea, as well in any part of the world that has or can build the necessary intellectual base as it has in America.

Though Sea Grant was founded on the original Land Grant triad of education, extension and experiment, in practice it has expanded and improved on the concepts to apply the methodologies to a much broader spectrum of the challenges and obligations of contemporary society. The specific nature of needs and opportunities in different localities may vary, but the methodology of their treatment is the same, as is the potential role of the university. Thus, it may be that Sea Grant, itself founded on the lessons of Land Grant, may already have pointed the way for Land Grant and other institutions of higher learning to make their educational and public service roles more directly responsive to the communities they serve—wherever their location and whatever their cultural, environment, and resource orientations. After all, Sea Grant is nothing more than a more effective way to use that singular human quality, the ability to reason.

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